

Chapter Nine: Conservation Strategies, by Habitat

A. Large-scale Habitats

1. Connecticut River and Merrimack River Mainstems

Habitat Description

The 410-mile-long Connecticut River is New England's longest river. Its headwaters are Fourth Connecticut Lake at the Canadian border, and it empties into Long Island Sound at Old Saybrook, Connecticut. The watershed encompasses an area of over 11,000 square miles, includes parts of four states (Connecticut, Massachusetts, New Hampshire and Vermont) and is home to 2.3 million people. The river drops 2,400 feet from its source to the sea, and has a daily average flow of nearly 16,000 cubic feet per second (cfs). The flow has ranged as high as 282,000 cfs and as low as 971 cfs. The lower 60 miles of the River are tidal, with the boundary between salt and freshwater about 17 miles inland from its mouth under normal conditions. Its waters represent 70% of the freshwater inflow to Long Island Sound. The Connecticut River has 38 major tributaries, 26 of which drain 100 square miles or more. All told, there are over 20,000 miles of streams in the watershed. Within Massachusetts there are 65 miles of mainstem river habitat. About one-third of that length is impounded behind two major hydroelectric dams, one at Holyoke and one at Turners Falls.

Mainstem river habitats are characterized by wide, low gradient streambeds meandering through broad river valleys with extensive flood plains. Rapid or riffle habitat is extremely rare. Channel formation occurs during periods of extreme flow (often described by the period of occurrence; e.g., 100-year or 500-year floods).

The following information was excerpted from the Commonwealth of Massachusetts, Executive Office of Environmental Affairs, Department of Environmental Protection Watershed Assessment Reports, written for the Connecticut and Merrimack River Watersheds. They include, segment by segment, brief but valuable summaries of the activities and stresses ongoing within the watersheds. These summaries help to illustrate the reasons many of the CWCS habitats are included in this document. These descriptions will help us create Conservation Strategies and implement the CWCS.

The following is excerpted from the full Connecticut River Watershed Assessment, available on the Web at <http://www.mass.gov/dep/brp/wm/wqassess.htm> .

CONNECTICUT RIVER BASIN 1998 WATER QUALITY ASSESSMENT REPORT

The Connecticut River and its tributaries constitute the largest river basin in New England. It has a maximum length of approximately 280 miles, a maximum width of about 60 miles and a total drainage area of approximately 11,250 square miles. From its origin in the Connecticut Lakes Region near the Canadian border, the 410-mile Connecticut River flows southward to form the boundary between New Hampshire and Vermont. It then flows through Massachusetts and Connecticut to the Long Island Sound. The river provides 70-80% of the freshwater entering the sound and is an integral part of its ecosystem (NEIWPCC 1997). The Connecticut River traverses approximately 67 river miles and drains approximately 2,726 square miles within Massachusetts.

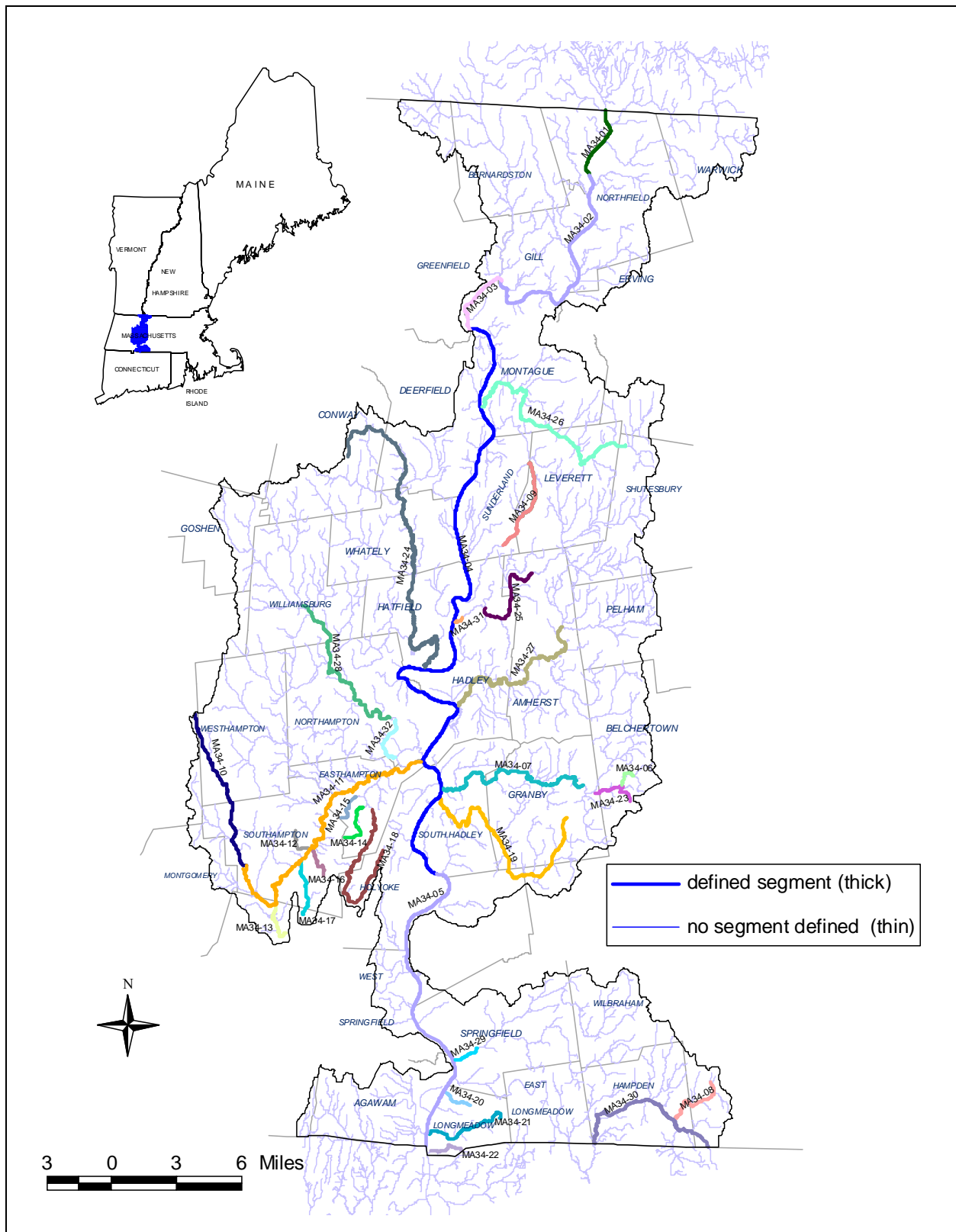


Figure 17: River Segment Locations in the Connecticut River Basin.

Connecticut River (Segment MA34-01)

Location: New Hampshire/Vermont/Massachusetts state line to Route 10 bridge, Northfield.

Segment Length: 3.5 miles.

Classification: Class B, Warm Water Fishery.

Major land-use estimates (top three uses) for the subwatershed (Figure 18, gray shaded area):

Forest	79%
Agriculture	9%
Residential	5%

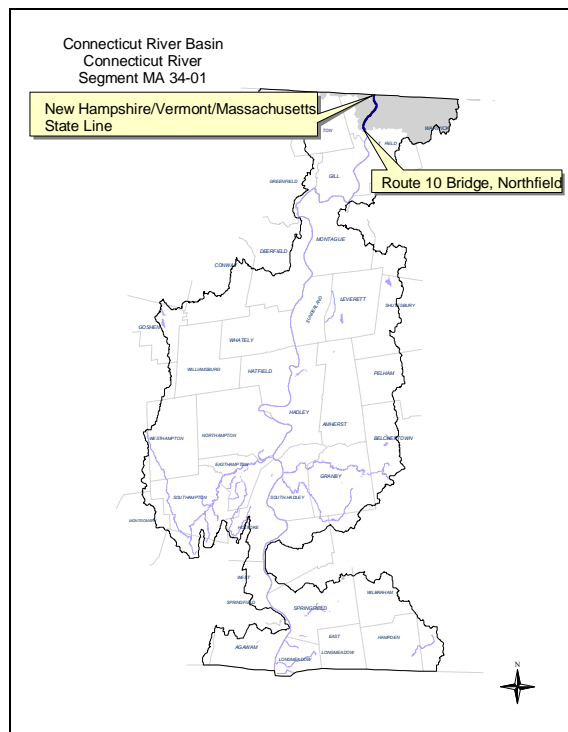


Figure 18: Connecticut River Segment 34-01.

The Connecticut River from Vernon, Vermont to Turners Falls, Massachusetts, is commonly known as the Turners Falls Power Pool. This segment (MA34-01) is entirely contained within the 22 mile Turners Falls Power Pool. Three hydroelectric generating facilities directly impact the day to day hydrodynamics of the Turners Falls Power Pool: Vernon, VT, Turners Falls, and Northfield Mountain. The joint operation of the Turners Falls and the Northfield projects has significantly changed the daily regime of the river in this pool, resulting in larger and quicker pool fluctuations (Franklin Regional Council of Governments and Connecticut River Streambank Erosion Committee 1999).

The 1979 “Report on Connecticut River Streambank Erosion Study” Report by the Army Corps of Engineers (ACOE) attempted to identify the causes of erosion and rate the importance of each. In addition to natural causes such as shear stress and stage variation, the report identified pool fluctuations and boat waves as contributing erosional factors. Pool fluctuations were named as

causing an increase in bank instability on the order of 18% of the shear stress exerted in the bank merely by flowing water. The report also identifies the difference in the nature of the erosion caused by wave action, which only works at the level of the water; and the various shear stress forces that work on the full height of the submerged bank, where the maximum shear stress is exerted on the bank below water at about 2/3 of the water's depth (Franklin Regional Council of Governments and Connecticut River Streambank Erosion Committee 1999).

In July of 1991, the ACOE completed a follow-up report on the erosion in the Turners Falls Pool, "General Investigation Study, Connecticut River Streambank Erosion: Connecticut River, Turners Falls Dam to State Line, MA." This study concluded that the riverbank erosion had increased almost threefold since 1979, with approximately one-third of the shoreline undergoing active erosion (Franklin Regional Council of Governments and Connecticut River Streambank Erosion Committee 1999).

Water Withdrawal Summary:

Facility	PWS ID #	WMA Permit #	WMA Registration #	Authorized Average Withdrawal	1998 Average Withdrawal
East Northfield Water Company	1217001-01S	9P2-1-06-217.02		0.14 MGD	0.089 MGD
Northfield Water District	1217000-01G				0.069 MGD
Linden Hill School	1217006-01G 1217006-02G			No safe yield	0.0017 MGD
<i>Total withdrawal</i>				<i>0.14 MGD</i>	<i>0.1597 MGD</i>

NPDES Wastewater Discharge Summary:

MA0100200 – Northfield WPCF (an extended aeration plant) is authorized to discharge 0.275 MGD to this segment of the Connecticut River. The permit limits for whole effluent toxicity are $LC_{50} \geq 50\%$ effluent. The facility's average daily flow for 1999 was 0.138 MGD. The facility has complied with its permit limits for the last three years (McCollum 2000). Effluent ammonia concentrations ranged between < 0.10 mg/L and 9.34 mg/L, and TRC measurements ranged between < 0.01 mg/L and 0.45 mg/L. The current NPDES permit expires at midnight on 29 September 2000.

Use Assessment

Aquatic Life

Biology

Habitat/Flow

Three hydroelectric generating facilities directly impact the day to day hydrodynamics of the Turners Falls Power Pool: Vernon, VT, Turners Falls, and Northfield Mountain. The Connecticut River Water Quality Assessment Report prepared for the New Hampshire Connecticut River Valley Resource Commission and the Vermont Connecticut River Watershed Advisory Commission identified organic enrichment, sedimentation, turbidity, and flow alteration as probable causes of impairment (partial support) in their most downstream segment of the Connecticut River (NH DES and VT DEC 1994).

In the Turners Falls Pool section of the Connecticut, the banks of the river, which are often twenty or more feet above the water level, are characterized by slumping and mass wasting

of huge sections of bank, with trees and other riparian vegetation frequently falling and sliding into the water (Franklin Regional Council of Governments and Connecticut River Streambank Erosion Committee 1999). Evidence of extreme erosion prompted a Connecticut River Watershed Restoration 319 Project that was conducted between 1996 and 1998. As part of this project conducted by the Franklin Regional Council of Governments and the CRSEC, two sites in this segment of the Connecticut River were selected for streambank restoration via design and installation of bioengineered bank stabilization (Franklin Regional Council of Governments and Connecticut River Streambank Erosion Committee 1999).

- The Wickey Site was located on the western side of the river. Banks were high and steeply eroded as a result of mass wasting-type erosion, with bare slopes and no trees remaining on the top of the bank. Construction at the Wickey Site (330 feet in length) was conducted in the fall/winter of 1996, and planting was conducted between fall of 1996 and spring of 1997.
- The Crooker site was located on the west bank of the river just upstream of the Route 10 bridge. Banks at the site were steep and extremely eroded. A total of 760 feet of bank was constructed in the summer of 1997, and planted between the fall of 1997 and the fall of 1998.

Toxicity

Ambient

Northfield WPCF collects Connecticut River water (from the boat ramp north of Schell Bridge in Northfield) for use as dilution water in their whole effluent toxicity tests. Between May 1996 and May 1999, survival of *Ceriodaphnia dubia* and *Pimephales promelas* exposed (48-hour) to the river water was not less than 75%.

Effluent

Northfield WPCF also conducted six effluent toxicity tests on *C. dubia* and *P. promelas* between May 1996 and May 1999 and two additional tests using *C. dubia* in May 1998 and August 1999. The LC₅₀'s were all \geq 100% effluent.

Chemistry – water pH

Measurements of pH in the Connecticut River (from the boat ramp north of Schell Bridge in Northfield) reported in Northfield WPCF toxicity testing reports ranged between 6.9 SU and 7.6 SU.

Suspended Solids

Measurements of SS in the Connecticut River (from the boat ramp north of Schell Bridge in Northfield) reported in Northfield WPCF toxicity testing reports ranged between <10 mg/L and 16 mg/L.

Ammonia-Nitrogen

Dilution water measurements of ammonia (as N) in the Connecticut River (from the boat ramp north of Schell Bridge in Northfield) reported in the Northfield WPCF toxicity testing reports ranged between <0.05 mg/L and 0.40 mg/L.

Total Residual Chlorine

TRC was not detected in the Connecticut River (from the boat ramp north of Schell Bridge in Northfield) as reported in the Northfield WPCF toxicity testing reports.

Hardness

Measurements of hardness in the Connecticut River (from the boat ramp north of Schell Bridge in Northfield) reported in Northfield WPCF toxicity testing reports ranged between 26 mg/L and 44 mg/L.

Chemistry - tissue

Results of the USGS NAWQA study documented elevated levels of total PCB in fish at four sampling stations along the mainstem Connecticut River which exceeded the NAS/NAE guidelines for the protection of fish-eating wildlife (Coles 1998). While this dataset however is limited to only one sample per station, the presence of PCB in fish throughout the entire mainstem Connecticut River (in MA), places the *Aquatic Life Use* on “Alert Status”.

This segment of the Connecticut River is assessed as partially supporting the *Aquatic Life Use* based on flow and habitat alteration. PCB contamination has also been identified as an issue of concern (“Alert Status”) for this use.

Fish Consumption






MA DPH issued a fish consumption advisory for the Connecticut River (all towns between Northfield and Longmeadow), recommending that children younger than 12 years, pregnant women, and nursing mothers should not eat any fish from the Connecticut River and the general public should not consume channel catfish, white catfish, American eel, or yellow perch because of elevated levels of PCB (MA DPH 1999).

Data used to issue the fish consumption advisory for the Connecticut River (PCB contamination) are now approximately ten years old. As a result, questions as to whether contamination levels are better or worse today, or whether the levels of contamination are higher in the same fish species in different reaches of the river cannot be answered. A work plan for *Fish Tissue Testing in the Connecticut River* was developed by the Connecticut River Forum in 1999. Fish sampling for this project was initiated in 2000. This project is being managed by NEIWPC and US EPA NERL.

Because of the MA DPH fish consumption advisory, the entire 3.5 miles of this segment do not support the *Fish Consumption Use*.

Connecticut River (Segment MA34-01) Use Summary Table

Designated Uses	Status	Causes	Sources
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Aquatic Life*		PARTIAL SUPPORT	Flow alteration, habitat alteration	Hydromodification, habitat modification
Fish Consumption		NON SUPPORT	PCB contamination	Unknown
Primary Contact		NOT ASSESSED		
Secondary Contact		NOT ASSESSED		
Aesthetics		NOT ASSESSED		

* “*Alert Status*” issues identified – details in Chemistry-tissue

RECOMMENDATIONS Connecticut River (Segment MA34-01)

- Historically, elevated fecal coliform bacteria levels were documented in this segment of the Connecticut River. Monitoring of fecal coliform bacteria should be conducted under both wet and dry sampling conditions to evaluate the status of the *Primary* and *Secondary Contact Recreational* uses.
- Review the results of the *Fish Tissue Testing in the Connecticut River* study developed by the Connecticut River Forum in 1999.
- Evaluate the effectiveness of streambank stabilization projects (for both immediate and long-term effects) along this segment of the Connecticut River.
- Specific recommendations from the 1994 Connecticut River Water Quality Assessment Report applicable to this segment of the Connecticut River include the following (NH DES and VT DEC 1994):
- The effects of dams on water quality and aquatic life in the Connecticut River and its tributaries should be comprehensively reviewed by state and federal resource agencies to balance the hydropower generation use with water quality uses and values.
- River and streambank erosion is a major problem for the Connecticut River, its tributaries, and adjacent landowners; habitat assessment to evaluate river siltation and embeddedness should be included in the erosion surveys. Further research on erosion causes and remediation options should be conducted. Implementation of river and streambank stabilization projects should continue to be a high priority for funding (native vegetation should be utilized to the greatest extent possible). Maintenance of vegetated riparian buffers is recommended and should be a part of any river and streambank restoration project.
- Within the limits of available funding, state agencies and volunteer monitors should expand their water quality assessment techniques to include a mix of physical habitat surveys and chemical, bacteriological, and biological sampling to better assess the overall health of the surface waters in the Connecticut River Watershed. Additional site-specific assessment of the impact of dams on water quality is needed. Macroinvertebrate and fish sampling studies bracketing sources suspected of pollution is needed.

Point source

- Reissue Northfield WPCF NPDES permit (MA0100200) which expires at midnight on 29 September 2000. Evaluate the need to address far field nutrient loading from this facility to Long Island Sound. Evaluate the need to obtain a Phase 2 storm water permit.
- Operations of the FERC Licensees (Project #2485 Northfield Mountain Power Station, Project # 1889 Turners Falls Station (Connecticut River) and Project # 2622 Turners Falls (Connecticut Canal) and the Vernon, VT Station) should be reexamined to develop a plan minimize streamflow fluctuations which are known to contribute to streambank erosion in the Turners Falls Power Pool. Site specific studies should be required of the licensees at both the impoundments and downstream of the dams. State agencies should evaluate site specific chemistry data within impoundments to document dissolved oxygen and the extent of algal problems. New Hampshire, Vermont [and Massachusetts] should coordinate their respective 401 certificate review with the goal of consistent conditions and monitoring requirements (NH DES and VT DEC 1994).

Connecticut River (Segment MA34-02)

Location: Route 10 bridge, Northfield to Turners Falls Dam, Gill/Montague.

Segment Length: 10.9 miles.

Classification: Class B, Warm Water Fishery.

Major land-use estimates (top three uses) for the subwatershed (Figure 19, gray shaded area):

Forest	72%
Agriculture	12%
Residential	5%

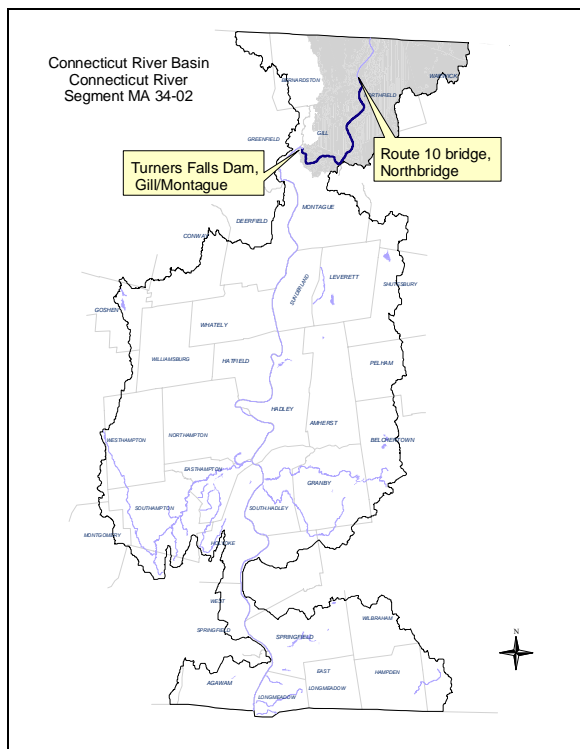


Figure 19: Connecticut River Segment 34-02.

This segment of the Connecticut River (MA34-02) is entirely contained within the 22 mile Turners Falls Power Pool. One of the three hydroelectric generating facilities that directly impacts the day to day hydrodynamics of the Turners Falls Power Pool is located within this segment, namely the Northfield Mountain Pumped Storage Project. The joint operation of the Turners Falls and the Northfield projects has significantly changed the daily regime of the river in this pool, resulting in larger and quicker pool fluctuations than would naturally occur (Franklin Regional Council of Governments and Connecticut River Streambank Erosion Committee 1999).

The Northfield Mountain Pumped Storage Project located about five miles upstream of the Turners Falls dam, consists of an upper reservoir and an underground pumping and generating plant which uses reversible pump turbine units. The Project also relies on the Turners Falls Pool to serve as a lower reservoir. During periods of low electrical demand, the Northfield Mountain

Pumped Storage Facility pumps water from the lower reservoir to the upper reservoir using the pump turbine generators. The water is then released during periods of high electrical demand, again through the pump turbine generators. In this way, the project is able to generate a maximum of 1080 megawatts of electricity. The increase in dam height over time, from 163.9 feet in 1867 to 185.5 feet in 1970 (21.6 feet in 103 years), has significantly altered the hydrodynamics of the reach. The joint operation of the Turners Falls and the Northfield projects has also significantly changed the daily regime of the river in the Turners Falls Pool, resulting in larger and quicker pool fluctuations. Typically, pool fluctuations may average as much as 3.5 feet per day, and much higher fluctuations (9-10.5 feet) may occur over the weekly cycle (Franklin Regional Council of Governments and Connecticut River Streambank Erosion Committee 1999).

[NOTE : Rare Species Habitat - The main stem of the Connecticut River here has been identified as Estimated Habitat for Rare Wildlife, including Bass Swamp, Millers Brook tributaries in the vicinity of Pratt Hollow and the Gulf Road, and the area around Sawyers Ponds (McCollum 2000). Fisheries – Mill Brook and Fourmile Brook, both tributaries to this segment of the Connecticut River, are stocked with salmon fry by the Massachusetts Division of Fisheries and Wildlife as part of the ongoing Atlantic Salmon Restoration Program (McCollum 2000).]

Water Withdrawal Summary:

Facility	PWS ID#	WMA Permit #	WMA Registration #	Authorized Average Withdrawal	1999 Average Withdrawal
<i>Reach 02A Route 10 Bridge in Northfield downstream to confluence with Millers River.</i>					
French King Motor Inn	1091009-01G				NM/NE*
Northfield Mt. Station and Visitors Center	1217003-01G 1217003-02G				0.0005 MGD 0.0023 MGD
Riverview Picnic Area	1217005-01G				0.0003 MGD
Lane Construction		9P-1-06-217.01		Below threshold Withdrawn	
<i>Reach 02B Confluence with Millers River downstream to Turners Falls Dam in Montague.</i>					
Purple Meadow Campground, Bernardston	1029001-01G				0.0005 MGD
Northfield Mount Herman School, Gill	1106002-01G				0.0700 MGD
Gill Elementary School, Gill	1106004-01G				0.0005 MGD
Pioneer Valley Regional High School, Northfield	1029001-01G				Not metered
Barton's Cove Campground	1106006-01G				0.0003 MGD
Alan's Bar B Que	1106007-01G				NM/NE
AquaFutures AquaPartners		9P-1-06-192.02		0.41 MGD	0.251 MGD
<i>Total Withdrawal</i>				<i>0.41 MGD</i>	<i>0.3254 MGD</i>

* NM/NE Not Metered/No Estimate

NPDES Wastewater Discharge Summary:

Reach 02A Route 10 Bridge in Northfield downstream to confluence with Millers River.

MA0032573- Northfield Mt. Hermon School WWTP is authorized to discharge 0.45 MGD to this segment of the Connecticut River. The permit limits for whole effluent toxicity are $LC_{50} \geq 50\%$ effluent. The facility's average daily flow for 1999 was 0.102 MGD. The facility consists of three aerated lagoons with an overall detention time of 30 days, followed by a clariflocculator. While the school has some inflow and infiltration problems, due to the detention time of the lagoons the facility has consistently met its permit limits for the last three years (McCollum 2000). Effluent measurements of TRC ranged between 0.02 mg/L and 0.45 mg/L, and ammonia (as N) concentrations ranged between 0.76 mg/L and 8.25 mg/L. The current NPDES permit expires at midnight on 29 September 2000.

MA0035530 – Western Massachusetts Electric Company, Northfield Mountain Station (owned by Northeast Utilities Service Company) is a hydroelectric station producing electricity. Their 2000 permit application indicates two outfalls 002 (tailrace) and 003 surface discharge swale which both discharge to the Connecticut River. Their application states 44.2 million gallons per year (MGY) annual water consumption with the following effluent characteristics: 66 MG average monthly and 2.2 MGD maximum daily, 4-13 °C average monthly and 13 °C maximum daily and pH limits are 6.8-7.4 SU average monthly and 7.4 SU average monthly. The facility also has a FERC permit (see below).

Reach 02B Confluence with Millers River downstream to Turners Falls Dam in Montague.

MA0110264 – Fins Technology WWTP (permit transfer 15 December 1999, formerly AquaFuture, Inc. or Aqua Partners Technologies, LLC). This facility is located just upstream from the dam and on the south side of the river in Montague along River Rd. The permit expires at midnight on 21 October 2000. The facility's average daily flow for 1999 was 0.149 MGD with a permit limit of 0.5 MGD. The facility raises striped bass. The treatment facility consists of two primary settling tanks, two submerged biofilters and a drum filter. Solids are stored in a fish manure tank. The supernatant from the tank discharges to the Town of Montague's sewer system. The facility has complied with its permit limits for the last three years (McCollum 2000).

FEDERAL ENERGY REGULATORY COMMISSION (FERC):

Project Name	Owner	Project #	Issue Date	Expiration Date	River	Kilowatts
Northfield Mountain Power Station	Western MA Electric Co.	2485	14 May 1968	30 April 2018	Connecticut River	1,000,000

Use Assessment

Aquatic Life

Biology

Habitat/Flow

Three hydroelectric generating facilities directly impact the day to day hydrodynamics of the Turners Falls Power Pool: Vernon, VT, Turners Falls, and Northfield Mountain. The Connecticut River Water Quality Assessment Report prepared for the New Hampshire Connecticut River Valley Resource Commission and the Vermont Connecticut River Watershed Advisory Commission identified organic enrichment, sedimentation, turbidity, and flow alteration as probable causes of impairment (partial support) in their most downstream segment of the Connecticut River (NH DES and VT DEC 1994).

The banks of the Connecticut River in the Turners Falls Pool section are often twenty or more feet above the water level, and are characterized by slumping and mass wasting of huge sections of streambank. Trees and other riparian vegetation frequently fall and slide into the water (Franklin Regional Council of Governments and Connecticut River Streambank Erosion Committee 1999). Evidence of extreme erosion prompted a Connecticut River Watershed Restoration 319 Project that was conducted between 1996 and 1998. As part of this project conducted by the Franklin Regional Council of Governments and the CRSEC, one site in this segment of the Connecticut River was selected for streambank restoration via design and installation of bio-engineered bank stabilization (Franklin Regional Council of Governments and Connecticut River Streambank Erosion Committee 1999).

- Streambanks at the Shearer Site were steeply eroded with high bare slopes. Construction at the Shearer Site (1160 feet in length) began in early November and continued through Christmas 1996. Planting was conducted in the winter of 1996 and repairs were made in the spring of 1997.

Toxicity

Ambient

Northfield Mt. Hermon School WWTP collects Connecticut River water (south of Bailey Brook in Gill) for use as dilution water in their whole effluent toxicity tests. Between May 1996 and May 2000, survival of *C. dubia* exposed (48-hour) to the river water was not less than 95%.

Effluent

Northfield Mt. Hermon School WWTP also conducted eight effluent toxicity tests on *C. dubia* between May 1996 and May 2000. The LC₅₀'s were all \geq 100% effluent.

Chemistry - water

pH

Measurements of pH in the Connecticut River (south of Bailey Brook in Gill) reported in the Northfield Mt. Hermon School toxicity testing reports ranged between 6.9 SU and 7.4 SU.

Suspended Solids

Except for one data point (53 mg/L), measurements of suspended solids in the Connecticut River (south of Bailey Brook in Gill) reported in the Northfield Mt. Hermon School toxicity testing reports were all less than 6 mg/L.

Ammonia-Nitrogen

Measurements of ammonia (as N) in the Connecticut River (south of Bailey Brook in Gill) reported in the Northfield Mt. Hermon School toxicity testing reports ranged between <0.05 mg/L and 0.34 mg/L.

Total Residual Chlorine

Measurements of TRC in the Connecticut River (south of Bailey Brook in Gill) reported in the Northfield Mt. Hermon School toxicity testing reports were between < 0.02 mg/L and 0.05 mg/L.

Hardness

Measurements of hardness in the Connecticut River (south of Bailey Brook in Gill) reported in the Northfield Mt. Hermon School toxicity testing reports ranged between 26 and 52 mg/L.

Chemistry - tissue

Results of the USGS NAWQA study documented elevated levels of total PCB in whole fish collected at four sampling stations along the mainstem Connecticut River which exceeded the NAS/NAE guidelines for the protection of fish-eating wildlife (Coles 1998). While this dataset however is limited to only one sample per station, the presence of PCB in fish throughout the entire mainstem Connecticut River (in MA), places the *Aquatic Life Use* on “Alert Status”.

This segment of the Connecticut River is assessed as partially supporting the *Aquatic Life Use* based on flow and habitat alteration. PCB contamination has also been identified as an issue of concern (“Alert Status”) for this use.






Fish Consumption

MA DPH issued a fish consumption advisory for the Connecticut River (all towns between Northfield and Longmeadow), recommending that children younger than 12 years, pregnant women, and nursing mothers should not eat any fish from the Connecticut River and the general public should not consume channel catfish, white catfish, American eel, or yellow perch because of elevated levels of PCB (MA DPH 1999).

Data used to issue the fish consumption advisory for the Connecticut River (PCB contamination) are now approximately ten years old. As a result, questions as to whether contamination levels are better or worse today, or whether the levels of contamination are higher in the same fish species in different reaches of the river cannot be answered. A work plan for *Fish Tissue Testing in the Connecticut River* was developed by the Connecticut River Forum in 1999. Fish sampling for this project was initiated in 2000. This project is being managed by NEIWPC and US EPA NERL.

Because of the MA DPH fish consumption advisory, the entire 10.9 miles of this segment do not support the *Fish Consumption Use*.

Connecticut River (Segment MA34-02) Use Summary Table

Designated Uses		Status	Causes	Sources
Aquatic Life*		PARTIAL SUPPORT	Flow alteration, habitat alteration	Hydromodification, habitat modification
Fish Consumption		NON SUPPORT	PCB contamination	Unknown
Primary Contact		NOT ASSESSED		
Secondary Contact		NOT ASSESSED		
Aesthetics		NOT ASSESSED		

* “**Alert Status**” issues identified – details in [Chemistry-tissue](#)

RECOMMENDATIONS Connecticut River (Segment MA34-02)

- Historically, elevated fecal coliform bacteria levels were documented in this segment of the Connecticut River. Monitoring of fecal coliform bacteria should be conducted under both wet and dry sampling conditions to evaluate the status of the *Primary* and *Secondary Contact Recreational* uses.
- Review the results of the *Fish Tissue Testing in the Connecticut River* study developed by the Connecticut River Forum in 1999.
- Investigate the amount of natural erosion compared to erosion associated with anthropogenic sources (hydropower, recreation, agriculture, etc.).
- Evaluate the effectiveness of streambank stabilization projects (for both immediate and long-term effects) along this segment of the Connecticut River.
- Specific recommendations from the 1994 Connecticut River Water Quality Assessment Report applicable to this segment of the Connecticut River include the following (NH DES and VT DEC 1994):
 - The effects of dams on water quality and aquatic life in the Connecticut River and its tributaries should be comprehensively reviewed by state and federal resource agencies to balance the hydropower generation use with water quality uses and values.
 - River and streambank erosion is a major problem for the Connecticut River, its tributaries, and adjacent landowners; habitat assessment to evaluate river siltation and embeddedness should be included in the erosion surveys. Further research on erosion causes and remediation options should be conducted. Implementation of river and streambank stabilization projects should continue to be a high priority for funding (native vegetation should be utilized to the greatest extent possible). Maintenance of vegetated riparian buffers is recommended and should be a part of any river and streambank restoration project.
 - Within the limits of available funding, state agencies and volunteer monitors should expand their water quality assessment techniques to include a mix of physical habitat surveys and chemical, bacteriological, and biological sampling to better assess the overall health of the surface waters in the Connecticut River Watershed. Additional site-specific assessment of the impact of dams on water quality is needed. Macroinvertebrate and fish sampling studies bracketing sources suspected of pollution is needed.

Point source

- MA0032573- Northfield Mt. Hermon School WWTP permit expires at midnight on 29 September 2000. Reissue the permit and determine the need for this facility to develop a long-term sludge disposal plan.
- MA0110264 – Fins Technology WWTP (formerly AquaFuture, Inc. or Aqua Partners Technologies, LLC) permit expires at midnight on 21 October 2000. Reissue permit.
- MA0035530 – Western Massachusetts Electric Company, Northfield Mountain Station (owned by Northeast Utilities Service Company) is a hydroelectric station producing electricity. A non-consumptive use determination was issued by MA DEP on 14 March 2000 for their facilities at Cabot Station, Turners Falls #1 and Northfield Mountain Project stations. However, if their NPDES application was correct (44.2 MGY annual water consumption) they may actually be subject to WMA regulations (36.5 MG over a calendar

year exceeds the WMA permit threshold) (LeVangie 2000). Confirm the permit application volumes and proceed with permitting actions (WMA, NPDES) as necessary.

[Note: The Water Management Act regulations (310 CMR 36:38) specifically define non-consumptive use as "any use of water which results in its being discharged back into the same water source at or near the withdrawal point in substantially unimpaired quality and quantity." Historically hydropower has been treated as a non-consumptive use. Those making such a withdrawal "must demonstrate to the satisfaction of the Department, that the volume of the water meets the definition of non-consumptive use in these regulations, and that no other existing registered or permitted withdrawers are substantially affected."]

- Operations of the FERC Licensees (Project #2485 Northfield Mountain Power Station, Project # 1889 Turners Falls Station (Connecticut River) and Project # 2622 Turners Falls (Connecticut Canal) and the Vernon, VT Station) should be reexamined (permit expires in 2018) to develop a plan minimize streamflow fluctuations which are known to contribute to streambank erosion in the Turners Falls Power Pool. Site specific studies should be required of the licensees at both the impoundments and downstream of the dams. State agencies should evaluate site specific chemistry data within impoundments to document dissolved oxygen and the extent of algal problems. New Hampshire, Vermont [and Massachusetts] should coordinate their respective 401 certificate review with the goal of consistent conditions and monitoring requirements (NH DES and VT DEC 1994).

Connecticut River (Segment MA34-03)

Location: Turners Falls Dam, Gill/Montague to confluence with Deerfield River, Greenfield/Montague/Deerfield.

Segment Length: 3.0 miles.

Classification: Class B, Warm Water Fishery.

Major land-use estimates (top three uses) for the subwatershed (Figure 20, gray shaded area):

Forest	71%
Agriculture	13%
Residential	6%

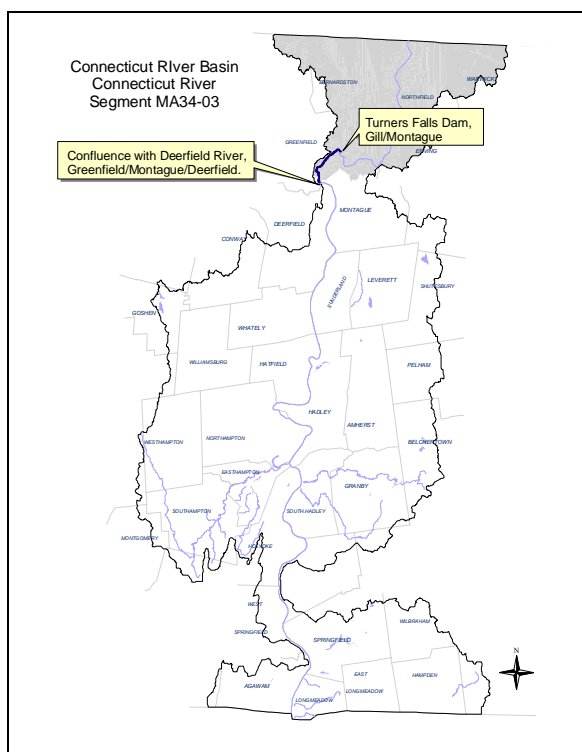


Figure 20: Connecticut River Segment 34-03.

Wetland Protection Interests

This watershed segment contains the Montague Plain, an extensive sand plain area that includes Pitch Pine-Oak, Pitch Pine/Scrub Oak and scrub oak shrubland and sandplain grassland vegetation communities. The Montague Plain area includes Estimated Habitats of Rare Wildlife, which are designated as Priority Habitats of Rare Species (there are a number of rare plant and animal species in this area). Montague Wildlife Management Area and one part of the Montague State Forest are located in the Montague Plain.

Additional habitat types in this segment include riverbank and river island communities associated with the Connecticut River (McCollum 2000).

The Connecticut River is diverted at Turner's Falls Dam into the Northeast Utility's power canal (7000 feet long by 120 feet wide) where it is used to generate hydroelectric power.

Approximately two miles of the mainstem Connecticut River are bypassed and water is returned to the Connecticut River at low flows via Cabot Station and at high flows via the Montague Dam and Cabot Station.

The US Geologic Survey operates Conte Lab, an anadromous fish laboratory on this segment of the Connecticut River. The Conte Anadromous Fish Lab is a world-class, fish passage and engineering research facility on 20 acres adjacent to the Connecticut River in northwestern Massachusetts. Laboratory staff conduct research on the ecological, physiological and behavioral characteristics of anadromous and migratory species. The lab plays a critical role in the evaluation, design and development of prototype fish passage facilities, particularly for migratory species that must negotiate around man-made barriers. The most frequently studied species are "anadromous" fishes who grow to maturity in salt water, but which migrate to rivers to spawn and spend a portion of their juvenile lives (USGS 2000).

[NOTE : Fisheries – Fall Brook, a tributary to this segment of the Connecticut River, is stocked with salmon fry by the Massachusetts Division of Fisheries and Wildlife as part of the ongoing Atlantic Salmon Restoration Program (Slater 2000).]

Water Withdrawal Summary:

Facility	PWS ID#	WMA Permit #	WMA Registration #	Authorized Average Withdrawal	1999 Average Withdrawal
Esleeck Mfg. Co., Inc., 80 Canal Street, Montague			1-06-192-03	0.880 MGD	0.688 MGD
Bernardston Fire & Water District, Bernardston (Sugarhouse Well)	1029000-03G	9P1-01-06-029.1		0.170 MGD	0.205 MGD
<i>Total withdrawals</i>				<i>1.050 MGD</i>	<i>0.893 MGD</i>

NPDES Wastewater Discharge Summary:

MA0005011 Esleeck Manufacturing Company, Inc. (formerly Strathmore Paper Company transferred September 1995). There are two permitted discharges from Esleeck Manufacturing (outfalls 001 and 003) neither of which have a maximum flow limit.

- Outfall 001 discharges water supply filter backwash into this segment of the Connecticut River. Transfer request letter from Esleeck indicates that this discharge is no longer active.
- Outfall 003 discharges into the Power canal and consists of combined (Strathmore and Esleeck paper companies) treated process wastewater. Benthic Oxygen Demand (BOD) permit limits for outfall 003 include a monthly average mass loading of 660 pounds/day BOD and a maximum daily limit 1320 pounds/day BOD. Total Suspended Solids (TSS) monthly average limits for this outfall are 500 pounds/day and a maximum daily limit 1000 pounds per day. A brief review of 1999 DMRs show average flow of approximately 0.7 to 0.8 MGD, with average daily discharges of 380 pounds/day and 100 pounds per day of BOD and TSS, respectively (equivalent to discharge concentrations of 65 mg/L BOD and 26 mg/L TSS). A review of the DMRs indicates that the facility has complied with its permit limits in recent years (McCollum 2000). The permit limits for whole effluent toxicity are $LC_{50} \geq 50\%$ effluent. The facility is also required to report the results of chronic toxicity testing (monitoring only required). Effluent ammonia concentrations reported in the Esleeck Manufacturing Company toxicity reports ranged between <0.02 mg/L and 1.80 mg/L. TRC was not detected in the effluent.

MA0003964 Esleek Manufacturing Company issued ?? in 1976 and expired in 1981. This facility is permitted to discharge non-contact cooling water, surface runoff, water wheel wastage and water wheel discharge through outfall 001 to the Connecticut River in Turner's Falls. Outfall #002 was eliminated in 1974. The permit has been administratively continued (expired permit remains in effect until a new permit is issued).

MA0035521 Cabot Station NEUSC/WME issued in 1995 and expires in September 2000. The NPDES reapplication file indicates seven (appears to be internal) outfalls (including sump for high water, groundwater drain pipes, transformer cooling pit, pit drains, floor drains, and water seal leakage at each unit) which ultimately discharge into one outfall into the Connecticut River.

FEDERAL ENERGY REGULATORY COMMISSION (FERC):

Project Name	Owner	Project #	Issue Date	Expiration Date	River	Kilowatts
Turners Falls	International Paper Company	2622	29 June 1999	28 February 2021	Connecticut Canal	937
Turners Falls	Western Massachusetts Electric Company	1889	05 May 1980	30 April 2018	Connecticut River	56,573

Western Massachusetts Electric Company's (WMECO) Turner's Falls project diverts water from the Connecticut River to generate hydroelectric power. The project is generally operated as run-of-river with negligible ponding (Monahan 2000). River water is deflected at the Gill Spillway into the Turner's Falls Dike. The Turner's Falls Station No. 1 is a base load plant and is operated at river flows between 12,000 cfs and 15,000 cfs. Water is held in a power canal that is 7000 feet long by 120 feet wide. This effectively renders about two miles of the mainstem Connecticut River into a virtually dry streambed for part of the year with most impact during the low-flow periods of the year (Hogan 2000). Water is returned to the Connecticut River at low flows via Cabot Station and at high flows via the Montague Dam and Cabot Station. The Cabot Station is operated during low flows as a peaking plant and during high flows (<12,000 cfs) it operates as a base load plant (Monahan 2000). The Federal Energy Regulatory Commission requires that a minimum flow of 1433 cfs (or a flow equal to the inflow into the reservoir) be released, although the minimum flow may be temporarily adapted during operating emergencies beyond WMECO's control or to protect fisheries resources and recreation. During fish migration season, 400 cfs is released from the dam. The flow from the dam then decreases to 125 cfs until November. From November to the fish migration season, all flow is released via the Cabot Station (Monahan 2000).

Use Assessment

Aquatic Life

Biology

Habitat/Flow

The Turner's Falls project diverts water into a power canal and renders about two miles (2.3) of the main stem river into a virtually dry stream bed for part of the year with most impact during the low-flow periods of the year (Hogan 2000).

Chemistry – water

Although no instream water quality sampling was conducted in the mainstem of the Connecticut River, data for the power canal (Esleeck Manufacturing Company toxicity testing reports) are summarized below:

Chemistry – sediment

USGS as part of their NAWQA study, analyzed sediment collected from the Connecticut River at Montague City. The concentration of total PCB was <50 PPM (Harris 1997). This sediment sample was comprised primarily of sand (88%) and silt (12%) while the total organic carbon (TOC) was 1.82%. Cadmium (0.6 PPM) was at the L-EL while chromium (90 PPM), copper (30 PPM), lead (33 PPM), nickel (34 PPM) and zinc (130 PPM) exceeded

POWER CANAL

Toxicity

Ambient

Esleeck Manufacturing Company collects Connecticut River water (50 yards upstream from their discharge to the power canal) for use as dilution water in their whole effluent toxicity tests. Between October 1996 and April 2000, survival of test organisms exposure to the river water was not < 80% (*C. dubia* ≥80% and *P. promelas* ≥85%) during the 7-day toxicity test.

Effluent

Esleeck Manufacturing Company also conducted 15 effluent toxicity tests on *C. dubia* and *P. promelas* between October 1996 and April 2000. The LC50's ranged between 56% and >100% effluent. CNOECs ranged from 25 to 100% effluent for *C. dubia* and <6.25 to 100% effluent for *P. promelas*. The test organism, *P. promelas*, was equally or more sensitive than the *C. dubia* in all chronic tests.

Chemistry - water

pH

Measurements of pH in the Power Canal (50 yards upstream from their discharge to the power canal) reported in the Esleeck Manufacturing Company toxicity testing reports ranged between 6.5 SU and 7.6 SU (Dallaire 2000a).

Suspended Solids

Measurements of suspended solids in the Power Canal (50 yards upstream from their discharge to the power canal) reported in the Esleeck Manufacturing Company toxicity testing reports ranged between < 5.0 mg/L and 250 mg/L with 33% greater than 25 mg/L.

Ammonia-Nitrogen

Measurements of ammonia in the Power Canal (50 yards upstream from discharge on the power canal) reported in Esleeck Manufacturing Company toxicity testing reports ranged between 0.03 mg/L and 0.16 mg/L.

Total Residual Chlorine

Esleeck Manufacturing Company toxicity testing reports detected no TRC in the Power Canal.

Hardness

Measurements of hardness in the Power Canal reported in the Esleeck Manufacturing Company toxicity testing reports ranged between 4 mg/L and 56 mg/L.

the L-EL guidelines (Persaud *et al.* 1993). Iron (4.7%) and manganese (1,600 PPM) exceeded the S-EL guidelines.

Chemistry – tissue

At the USGS NAQWA study site on the Connecticut River at Montague City the concentration of PCB in the whole fish composite sample (comprised of eight white suckers, *Catostomus commersoni*) was 820 µg/kg wet weight (Coles 1998). This level of PCB exceeded (1.6 times) the NAS/NAE guideline for total PCB (in Coles 1998) of 500µg/kg wet weight for the protection of fish-eating wildlife. Neither total DDT nor total chlordane exceeded the NAS/NAE guidelines. This dataset is too limited (one sample per station) to assess the *Aquatic Life Use* as non support thereby placing it on “Alert Status”.

Although Fall River discharges into this segment of the Connecticut River just below the Turner's Falls Dam, the majority of the Connecticut River is diverted through the power canal. This renders a reach of the Connecticut River into a virtually dry streambed for part of the year, and therefore the *Aquatic Life Use* is not supported for 2.3 miles. The lower 0.7 miles of this segment (downstream from the power canal) are assessed as partial support due to elevated suspended solids. PCB contamination has also been identified as an issue of concern ("Alert Status") for this use.






Fish Consumption

MA DPH issued a fish consumption advisory for the Connecticut River (all towns between Northfield and Longmeadow), recommending that "Children younger than 12 years, pregnant women, and nursing mothers should not eat any fish from the Connecticut River and the general public should not consume channel catfish, white catfish, American eel, or yellow perch because of elevated levels of PCB (MA DPH 1999).

Data used to issue the fish consumption advisory for the Connecticut River (PCB contamination) are now approximately ten years old. As a result, questions as to whether contamination levels are better or worse today, or whether the levels of contamination are higher in the same fish species in different reaches of the river cannot be answered. A work plan for *Fish Tissue Testing in the Connecticut River* was developed by the Connecticut River Forum in 1999. Fish sampling for this project was initiated in 2000. This project is being managed by NEIWPC and US EPA NERL.

Because of the MA DPH fish consumption advisory, the entire 3.0 miles of this segment do not support the *Fish Consumption Use*.

Connecticut River (Segment MA34-03) Use Summary Table

Designated Uses		Status	Causes	Sources
Aquatic Life*		NON SUPPORT Upper 2.3 miles PARTIAL SUPPORT Lower 0.7 miles	Flow alteration Unknown, suspended solids	Unknown, Hydromodification
Fish Consumption		NON SUPPORT	PCB contamination	Unknown
Primary Contact		NOT ASSESSED		
Secondary Contact		NOT ASSESSED		
Aesthetics		NOT ASSESSED		

* "**Alert Status**" issues identified – details in [Chemistry-tissue](#)

RECOMMENDATIONS Connecticut River (Segment MA34-03)

- Historically, elevated fecal coliform bacteria levels were documented in this segment of the Connecticut River. Monitoring of fecal coliform bacteria should be conducted under both wet and dry sampling conditions to evaluate the status of the *Primary* and *Secondary Contact Recreational* uses.
- Review the results of the *Fish Tissue Testing in the Connecticut River* study developed by the Connecticut River Forum in 1999.
- Investigate the amount of natural erosion compared to erosion associated with anthropogenic sources (hydropower, recreation, agriculture, etc.).
- Specific recommendations from the 1994 Connecticut River Water Quality Assessment Report applicable to this segment of the Connecticut River include the following (NH DES and VT DEC 1994):
 - The effects of dams on water quality and aquatic life in the Connecticut River and its tributaries should be comprehensively reviewed by state and federal resource agencies to balance the hydropower generation use with water quality uses and values.
 - River and streambank erosion is a major problem for the Connecticut River, its tributaries, and adjacent landowners; habitat assessment to evaluate river siltation and embeddedness should be included in the erosion surveys. Further research on erosion causes and remediation options should be conducted. Implementation of river and streambank stabilization projects should continue to be a high priority for funding (native vegetation should be utilized to the greatest extent possible). Maintenance of vegetated riparian buffers is recommended and should be a part of any river and streambank restoration project.
 - Within the limits of available funding, state agencies and volunteer monitors should expand their water quality assessment techniques to include a mix of physical habitat surveys and chemical, bacteriological, and biological sampling to better assess the overall health of the surface waters in the Connecticut River Watershed. Additional site-specific assessment of the impact of dams on water quality is needed. Macroinvertebrate and fish sampling studies bracketing sources suspected of pollution is needed.
- Elevated levels of suspended solids have been measured in the Power Canal (50 yards upstream from their discharge to the power canal) reported in the Esleek Manufacturing Company toxicity testing reports. Investigate possible sources of these conditions (e.g., erosion, runoff).

Point source

- The Turners Falls project diverts water into a power canal and renders about two miles of the main stem river into a virtually dry stream bed for part of the year with most impact during the low-flow periods of the year (Hogan 2000). Maximize streamflow to this segment of the Connecticut River. Operations of the FERC Licensees (Project # 1889 Turners Falls Station (Connecticut River) and Project # 2622 Turners Falls, Connecticut Canal) should be reexamined to develop a plan to maintain adequate flow in the by-pass reach of the Connecticut River for the protection of aquatic life.
- Evaluate stormwater controls/needs along the power canal.
- The NPDES permit MA0035521 for NEUSC/WME's Cabot Station in Montague that expired in September 2000 should be reissued with appropriate limits and monitoring requirements.

- Investigate the possibility of non-permitted CSO discharges into this segment of the Connecticut River in the village of Turners Falls (town of Montague). [Note: The 1983 sewer separation design for the Montague WPCF included a regulator structure (near 7th Street) expected to discharge approximately four times per year.] The current status of this structure needs to be determined (e.g., clogged). Remediate problem if necessary.
- Esleeck Manufacturing Company, Inc. (MA0005011) (formerly Strathmore Paper Company). Reduce toxicity testing requirements to one organism, *P. promelas* as it has been consistently more sensitive. Confirm whether or not Outfall #001 is still active and reissue the permit.
- Esleeck Manufacturing Company, Inc. (MA0003964) permit should be reissued.

Connecticut River (Segment MA34-04)

Location: Confluence with Deerfield River, Greenfield/Montague/Deerfield to Holyoke Dam, Holyoke/South Hadley.

Segment Length: 34.2 miles.

Classification: Class B, Warm Water Fishery.

Major land-use estimates (top three uses) for the subwatershed (Figure 21, gray shaded area):

Forest	66%
Agriculture	15%
Residential	9%

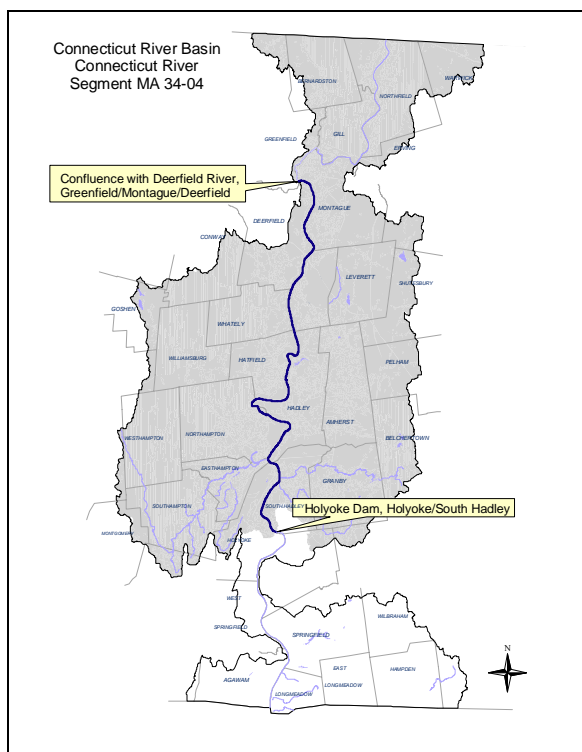


Figure 21: Connecticut River Segment 34-04.

Mechanical harvesting of water chestnut (*Trapa natans*), a non-native invasive aquatic plant, was conducted in Log Pond Cove, Holyoke as part of the 2000 Connecticut River Watershed Water Chestnut Control Activities. Funds for the mechanical harvesting projects came from the Region 5 Challenge Cost Share Program, the EOE, and Holyoke Water Power. Assistance in clearing the Log Pond Cove site was also provided by the Holyoke Department of Public Works. The Holyoke Conservation Department is overseeing the Log Pond Cove contract and work (Boettner 2000).

In addition to mechanical removal, Silvio Conte National Fish and Wildlife Refuge, under a grant from the National Fish and Wildlife Foundation has provided coordination for many hand-pulling events. Since early detection is key to control, EOE, through the Franklin, Hampden, and Hampshire Conservation Districts, have hired an intern who is recruiting volunteers to

actively check water bodies for the presence of water chestnut within the watershed of the mainstem of the Connecticut River. This “Invasive Plant Watch” program was made possible by a grant from the Riverways Program and the local conservation districts (Boettner 2000).

Seven reaches were used to organize water withdrawal and NPDES permitting information within this segment of the Connecticut River:

- Reach 04A: Confluence with Deerfield River downstream to confluence with the Sawmill River in Montague.
- Reach 04B: Confluence Sawmill River, Montague to confluence of Mill River in Hadley.
- Reach 04C: Connecticut River from confluence with Mill River-Hadley downstream to confluence with Mill River, Hatfield.
- Reach 04D: Confluence with Mill River-Hatfield downstream to confluence with Fort River, Hadley.
- Reach 04E: Connecticut River from confluence with Fort River downstream to the Oxbow in Northampton.
- Reach 04F: Connecticut River from Oxbow downstream to confluence with Bachelor Brook.
- Reach 04G: Connecticut River confluence with Bachelor Brook downstream to Holyoke Dam in Holyoke and South Hadley.

Water Withdrawal Summary:

Facility	PWS ID #	WMA Permit #	WMA Registration #	Authorized Average Withdrawal	1999 Average Withdrawal
Reach 04A: Confluence with Deerfield River downstream to confluence with the Sawmill River in Montague.					
Turners Falls Fire District, Montague	1192000-01G 1192000-02G 1192000-02S 1192000-03S	9P-1-06-192.01	1-06-192-01	1.040 MGD (reg) 0.120 MGD (per)	0.557 MGD 0.376 MGD 0 0
Montague Center Water District, Montague	1192001-01G				0.038 MGD
Deerfield Water District, Deerfield	1074000-02G Keats Spring				
DEM Lake Wyola Park & Campground, Shutesbury	1272001-01G				TNC (Transient non-community)
Camp Anderson Foundation, Wendell	1272003-01G				TNC
Red Wing Meadow Trout Hatchery, Montague		9P2-1-06-192.03	1-06-192-04	0.50 MGD (reg) 0.30 MGD (per)	0.72 MGD
Reach 04B: Confluence Sawmill River, Montague to confluence of Mill River in Hadley.					
South Deerfield Water Supply District, South Deerfield	1074001-01G	9P2-1-06-074.01	1-06-074-02	0.65 MGD*	0
Sunderland Water District, Sunderland	1289000-02G		1-06-289-05	0.24 MGD	0.34 MGD
Cliffside Apartments, Sunderland	1289001-01G 1289001-02G 1289001-03G				0.03 MGD
Pond Ridge Condo. Assn., Sunderland	1289002-01G				0.01 MGD
Reach 04C: Connecticut River from confluence with Mill River-Hadley downstream to confluence with Mill River, Hatfield.					
Hadley Highway & Water Dept., Hadley (Mt. Warner Wells)	1117002-01G 1117002-02G		1-06-117-02	0.79 MGD	0.403 MGD (01G) 0.341 MGD (02G)
Reach 04D: Confluence with Mill River-Hatfield downstream to confluence with Fort River, Hadley.					
Hadley Highway & Water Dept., Hadley (Callahan Wells)	1117002-03G 1117002-04G		1-06-117-02	0.79 MGD	0.001 MGD (03G) 0.0002 MGD (04G)
Reach 04E: Connecticut River from confluence with Fort River downstream to the Oxbow in Northampton.					

Facility	PWS ID #	WMA Permit #	WMA Registration #	Authorized Average Withdrawal	1999 Average Withdrawal
DEM Skinner State Park, Hadley	1117006-01G				0.002 MGD
Reach 04F: Connecticut River from Oxbow downstream to confluence with Bachelor Brook.					
Skinner State Park, Hadley	1117006-01G				TNC, no stats
South Hadley Fire District #1	1275000-01G	9P2-1-06-275.04			pending
South Hadley Fire District #2, South Hadley	1275001-04G		1-06-275-02	0.680 MGD	0.47
Reach 04G: Connecticut River confluence with Bachelor Brook downstream to Holyoke Dam in Holyoke and South Hadley.					
Holyoke Water Works, Holyoke	1137000-02S		1-06-137-11	Wtd from MA34-10	0 (emergency only)
Hazen Paper Company, Holyoke			1-06-137-01	.130 MGD	.036 MGD
Parsons Paper Co. Div. NVF, Holyoke			1-06-137-03	.590 MGD	.29 MGD
Wykoff Country Club, Holyoke			1-06-137-05	.040 MGD	.029 MGD
Sonoco Products Co., Holyoke			1-06-137-06	.850 MGD	.61 MGD
Holyoke Gas & Electric, Holyoke			1-06-137-08	.611 MGD	.173 MGD
Linweave Inc/Harris Energy & Realty, Holyoke			1-06-137-09	.716 MGD	Not in use in 1999
Mt. Tom Ski Area, Holyoke			1-06-137-10	1.130 MGD	Shut down
Kodak Polychrome Graphics – ANITEC, Holyoke		9P-1-06-137.01		.47 MGD	.25 MGD
Rexham Graphics, South Hadley			1-06-275-01	.200 MGD	0
South Hadley Golf Course, South Hadley		9P2-1-06-275.02			Not yet constructed
<i>Total Withdrawals</i>				<i>7.377 MGD</i>	<i>4.6762 MGD</i>

*Represents the pending permitted withdrawal for the entire system. 1074001-01G is designated as an emergency source only.

NPDES Wastewater Discharge Summary:

Reach 04A Confluence with Deerfield River downstream to confluence with Sawmill River in Montague.

MA0100137 – Montague WPC (a conventional secondary treatment plant) is authorized to discharge 1.83 MGD to this segment of the Connecticut River. The permit limits for whole effluent toxicity are LC 50 \geq 50% effluent. Montague WPC average daily flow for 1999 was 1.06 MGD. The facility has had past problems with filamentous bacteria. The facility accepts septage, however its septage receiving station needs to be upgraded. Long-term concerns involve the development of a combined sewer overflow (CSO) control plan for the Towns' one CSO on Greenfield Road (McCollum 2000). The facility is also required to develop and implement an industrial pretreatment program. The current permit expires at midnight on 29 September 2000.

MA0110051 – Bitzer Trout Hatchery is permitted to discharge 1.1MGD of fish raceway water to a tributary of the Connecticut River. The average daily flow for 1999 was 1.39 MGD. The facility consists of fish raceways with four sedimentation basins to collect solids. Groundwater from springs is utilized for flow and is beyond the control of the operators. Their permit expired at midnight on 22 April 2000.

MA0000272 - B&M Railroad Yard, East Deerfield discharges boiler blowdown, cooling water, and wash water to the Connecticut River. The permit expired in 1980 and has been administratively continued (expired permit remains in effect until a new permit is issued). In 1999, there were three flow exceedances and two failures to monitor (McCollum 2000).

Reach 04B Confluence Sawmill River, Montague to confluence of Mill River in Hadley.

MA0100218 – Amherst WWTP is a conventional secondary treatment plant that is permitted to discharge 7.1 MGD of treated municipal wastewater to the Connecticut River. The permit limits for whole effluent toxicity are $LC_{50} \geq 50\%$ effluent. The Amherst WWTP average daily flow for 1999 was 4.4 MGD. The plant has consistently met its permit limits within the last three years. The permit expired midnight 30 September 2000 (McCollum 2000).

MA0101648 – South Deerfield WWTP is an extended aeration plant capable of meeting secondary treatment standards. The facility is permitted to discharge 0.85 MGD of municipal wastewater to Connecticut River. The permit limits for whole effluent toxicity are $LC_{50} \geq 50\%$ effluent. South Deerfield WWTP average daily flow for 1999 was 0.77 MGD. The plant has consistently met its permit limits within the last three years. The facility's major issue is correction of inflow and infiltration (McCollum 2000). The current permit expired midnight 29 September 2000.

MA0101079 – Sunderland WWTP is an extended aeration plant permitted to discharge 0.5 MGD of municipal wastewater to the Connecticut River. The permit limits for whole effluent toxicity are $LC_{50} \geq 50\%$ effluent. The facility's average daily flow for 1999 was 0.179 MGD. The facility has complied with its permit limits for the last three years. The only long-term issue is the closure of the on-site unlined sludge storage lagoon and the development of a long-term sludge disposal method. Currently the facility no longer utilizes the lagoon and is under Department Order to close it (McCollum 2000). The current NPDES permit expired midnight 29 September 2000.

MA0101290 – Hatfield WWTP, a secondary treatment plant utilizing rotating biological contractors (RBCs), is permitted to discharge 0.5 MGD of treated municipal wastewater to the Connecticut River. The WWTP does not have primary settling, which is normally typical of RBC plants. The average daily flow for 1999 was 0.224 MGD. The permit limits for whole effluent toxicity are $LC_{50} \geq 50\%$ effluent. The facility has consistently met its permit limits for the last three years. The only long-term issue for the town is to pursue removal of inflow and infiltration in its sewer system (McCollum 2000). The permit expired midnight 29 September 2000.

Reach 04C - Connecticut River confluence with Mill River-Hadley to confluence with Mill River, Hatfield. None Identified

Reach 04D - Confluence with Mill River-Hatfield downstream to confluence with Fort River, Hadley.

MA0100099 – Hadley WWTP is a secondary treatment plant utilizing the extended aeration method for treatment and is permitted to discharge 0.54 MGD to the Connecticut River. The average daily flow for 1999 was 0.332 MGD. The permit limits for whole effluent toxicity are $LC_{50} \geq 50\%$ effluent. The facility has consistently met its permit limits for the last three years (McCollum 2000). The permit expired midnight 29 September 2000.

Reach 04E- Connecticut River from confluence with Fort River to the Oxbow in Northampton.

MA0101818 – The WWTP is a conventional secondary treatment plant permitted to discharge 8.6 MGD of treated municipal wastewater to the Connecticut River. The average daily flow for 1999 was 4.63 MGD. The permit limits for whole effluent toxicity are $LC_{50} \geq 50\%$ effluent. The only long term concerns involve the facility experiencing some inflow and infiltration in the collection system, but the facility has met permit limits in the last three years (McCollum 2000). The current permit expired midnight 29 September 2000. The facility will be required to develop and implement an industrial pretreatment program.

Reach 04F - Connecticut River from Oxbow downstream to confluence with Bachelor Brook.

MA0101478 – Easthampton WWTP is a conventional secondary treatment plant permitted to discharge 3.8 MGD of treated sanitary and industrial wastewater to the Connecticut River via Outfall 001 and if necessary (higher flows) to the Manhan River via Outfall 002. Outfall 001 discharges to this segment of the Connecticut River approximately ¼ mile downstream of its confluence with Manhan River in Easthampton (near the Holyoke Corporate Boundary line). The permit limits for whole effluent toxicity are $LC_{50} \geq 100\%$ effluent. The average daily flow in 1999 was 2.6 MGD. The plant has consistently met its permit limits within the last three years (McCollum 2000). The facility will be required to develop and implement an industrial pretreatment program. The permit expired on 29 October 2000.

Reach 04G - Connecticut River confluence with Bachelor Brook to Holyoke Dam, Holyoke/South Hadley.

MA0005339 Northeast Utilities, Holyoke Water Power Company, Mount Tom Station is a steam generating power plant which uses coal as its primary fuel source. The permit expired 18 September 1997 and has been administratively continued (expired permit remains in effect until a new permit is issued). The facility's monthly average flow for each outfall is summarized below:

001 – 133.2 MGD flow of once through non-contact cooling water. Chlorination is utilized for biofouling control. The permit limit for TRC is 0.15 mg/L, the maximum daily temperature limit is 39°C, and the maximum daily temperature rise from the intake to the discharge (with both pumps operating) is 11.1°C. Multi-unit chlorination is permitted.

002* – 0.216 MGD wastewater treatment plant effluent.

003, 004, 007, and 009a – stormwater runoff.

005 – 0.71 (normal maximum daily flow) of screen wash and service water tank overflow.

006 – 0.144 (maximum daily) of reflecting pool overflow.

008*, 009* – 0.25 MGD of bottom ash transport water (not used simultaneously).

010*, 011* – 1.0 MGD fly ash transport water (not used simultaneously).

*Required to monitor for Zinc and other metals. These outfalls currently discharge into unlined lagoons that then overflow to the Connecticut River.

[Note: Holyoke CSO Draft Environmental Impact Report (DEIR) was submitted for Massachusetts Environmental Policy Act Unit (MEPA) review on May 2000. This DEIR identified zinc concentrations exceeding Class B on the Connecticut River, at the northern limits of the Holyoke Corporate Boundary.]

MA0101630 – The Holyoke combined sewage collection system has 15 active permitted CSO outfalls that discharge an estimated 517 million gallons per year (MGY) of untreated combined sewage into the Connecticut River. The permit expired in October 2000. Five of these CSOs discharge to this segment of the Connecticut River. Holyoke’s three largest CSOs cumulatively discharge an estimated 414 MGY to the Connecticut River. Two of these outfalls discharge to this segment: Outfall 021 discharging an estimated 58 MGY and CSO Outfall 018 discharging an estimated 65 MGY. The following five CSOs discharge into the Connecticut River at the end of this segment.

CSO Outfall 021 River Terrace
 CSO Outfall 020 Cleveland Street
 CSO Outfall 023 Jefferson Street (I-IV) to “Dingle” Drainage Ditch
 CSO Outfall 019 Yale Street
 CSO Outfall 018 Walnut Street

Reach 04G: Connecticut River confluence with Bachelor Brook to Holyoke Dam, Holyoke/South Hadley

FEDERAL ENERGY REGULATORY COMMISSION (FERC):

Project Name	Owner	Project #	Issue Date	Expiration Date	River	Kilowatts
Hadley Falls	Holyoke Water Power Company	2004	20 August 1999	31 August 2039	Connecticut River	45,675

The Holyoke Dam Hydroelectric Project is an operating FERC licensed facility located on the Connecticut River in the city of Holyoke and the town of South Hadley. A complete description of the facility is presented in Segment MA34-05.

Use Assessment

Aquatic Life

Toxicity

Ambient and effluent toxicity data were summarized for eight NPDES permitted facilities which submitted whole effluent toxicity reports to MA DEP DWM that discharge to this segment of the Connecticut River. These facilities submitted a total of 52 acute whole effluent toxicity testing results on tests which were conducted between May 1996 and May 2000. The Holyoke WPCF (which discharges to the next downstream segment of the Connecticut River MA34-05) also collects dilution water from this segment increasing the ambient toxicity dataset to 70.

Ambient

Survival of test organisms *C. dubia* and *P. promelas* exposed (48-hour) to Connecticut River water exceeded 75% in all but one test event.

Effluent

In 96% of the test events neither *C. dubia* nor *P. promelas* exhibited whole effluent acute toxicity. Hatfield WWTP’s effluent was acutely toxic to *C. dubia* in two events in August 1996 and Easthampton WWTP’s effluent was acutely toxic to *C. dubia* in one event in December 1996.

Summary of TOXTD data: Connecticut River Segment MA34-03.

AMBIENT	EFFLUENT
<p><u>MONTAGUE WPCF</u> – end of Poplar Street, near sandbar Data set: 5 tests May 1996 – May 1999 Survival: <i>C. dubia</i> 100% 48 hours Suspended Solids: < 5.0 – 52 mg/L TRC: not detected pH: 7.3 – 7.6 SU Ammonia-nitrogen: 0.03 – 0.10 mg/L Hardness: 23 – 40 mg/L</p>	<p><u>MONTAGUE WPCF – Outfall 001A</u> Data set: 5 tests May 1996 – May 1999 LC₅₀: <i>C. dubia</i> ≥ 100% effluent. TRC: ≤0.03 mg/L Ammonia-nitrogen: 0.19 – 12 mg/L</p>
<p><u>SOUTH DEERFIELD WWTP</u> – North of Sunderland Bridge Data set: 8 tests August 1996 – May 2000 Survival: <i>C. dubia</i> ≥95% 48 hours Suspended Solids: < 4.0 – 5.50 mg/L TRC: not detected pH: 6.7 – 7.5 SU Ammonia-nitrogen: 0.03 – 0.16 mg/L Hardness: 23 – 41 mg/L</p>	<p><u>SOUTH DEERFIELD WWTP – Outfall 001A</u> Data set: 8 tests August 1996 – May 2000 LC₅₀: <i>C. dubia</i> ≥ 100% effluent TRC: ≤0.02 – 0.14 mg/L Ammonia-nitrogen: 0.06 – 8.1 mg/L</p>
<p><u>SUNDERLAND WWTF</u> – off Old Amherst Rd (Riverside Cemetery) Data set: 4 tests each species <i>C. dubia</i> May 1997 – August 1998 <i>P. promelas</i> May 1997- May 2000 Survival: both species 100% 48 hours Suspended Solids: <4.0 – 11 mg/L TRC: not detected pH: 7.1 - 7.6 SU Ammonia-nitrogen: 0.05 – 9 mg/L Hardness: 30 – 72 mg/L</p>	<p><u>SUNDERLAND WWTF</u> – Outfall 001 Data set: 4 tests each species <i>C. dubia</i> May 1997 – August 1998 <i>P. promelas</i> May 1997- May 2000 LC₅₀: <i>C. dubia</i> ≥ 100%, <i>P. promelas</i> 72 - >100% effluent TRC: ≤0.02– 0.1 mg/L Ammonia-nitrogen: <0.1 – 18 mg/L</p>
<p><u>AMHERST WWTP</u> – 100 yd. Upstream of discharge Data set: 8 tests May 1996 to May 2000 Survival: <i>C. dubia</i> 100% at 48 hours Suspended Solids: not detected TRC: 0.01 – 0.05 mg/L pH: 6.8 - 7.9 SU Ammonia-nitrogen: <0.07 – 0.08 mg/L Hardness: 24 – 44 mg/L</p>	<p><u>AMHERST WWTP</u> – Outfall 003B Data set: 8 tests May 1996 to May 2000 LC₅₀: <i>C. dubia</i> ≥ 100% effluent TRC: <0.01 – 0.05 mg/L Ammonia-nitrogen: 0.2 – 6.3 mg/L</p>
<p><u>HATFIELD WWTP</u> – Approx. 500' upstream discharge Data set: 7 tests May 1996 – May 2000 Survival: <i>C. dubia</i> ≥95% 48 hours, <i>P. promelas</i> 55 – 100% (low survival in 1 of 7 tests) Suspended Solids: <5.0 – 5.5 mg/L TRC: <0.01 – 0.09 mg/L pH: 6.1 – 7.6 SU Ammonia-nitrogen: 0.07 – 17 mg/L Hardness: 32 – 76 mg/L</p>	<p><u>HATFIELD WWTP</u> – Outfall 001 Data set: 7 tests May 1996 – May 2000 LC₅₀: <i>C. dubia</i> 9% - ≥ 100% effluent (2 acutely toxic events, both in August 1996), <i>P. promelas</i> 98 – >100% TRC: ≤0.01 – 0.12 mg/L Ammonia-nitrogen: 0.08 – 6.5 mg/L</p>
<p><u>HADLEY WWTP</u> – Boat dock at 29 Honey Pot Rd Data set: 8 tests August 1996 – May 2000 Survival: <i>C. dubia</i> ≥95%, <i>P. promelas</i> 100% 48 hours Suspended Solids: < 4.0 – 10 mg/L TRC: not detected pH: 6.4 – 7.6 SU Ammonia-nitrogen: <0.01 – 0.17 mg/L Hardness: 22 – 38 mg/L</p>	<p><u>HADLEY WWTP</u> – Outfall 001 Data set: 6 tests <i>C. dubia</i> May 1997 – May 2000, 4 tests <i>P. promelas</i> May 1997 – August 1998 LC₅₀: both species ≥ 100% effluent TRC: not detected Ammonia-nitrogen: 0.25 – 9.5 mg/L</p>

AMBIENT	EFFLUENT
<p><u>NORTHAMPTON POTW</u> – Approx. 300 yd. Upstream from outfall diffuser, upstream of Hockanum Rd.</p> <p>Data set: 9 tests May 1996 to May 2000</p> <p>Survival: <i>C. dubia</i> ≥95% 48 hours</p> <p>Suspended Solids: < 5.0 – 19.50 mg/L</p> <p>TRC: 0.01 – 0.06 mg/L</p> <p>pH: 6.5 – 7.5 SU</p> <p>Ammonia-nitrogen: 0.05- 0.15 mg/L</p> <p>Hardness: 27 – 40 mg/L</p>	<p><u>NORTHAMPTON POTW</u> – Outfall 001A</p> <p>Data set: 9 tests May 1996 to May 2000</p> <p>LC₅₀: <i>C. dubia</i> ≥ 100% effluent</p> <p>TRC: 0.03 – 0.52 mg/L</p> <p>Ammonia-nitrogen: 3.1 mg/L – 26 mg/L</p>
<p><u>EASTHAMPTON WWTP</u> – 15' upstream of discharge</p> <p>Data set: 5 tests June 1996 – December 1999</p> <p>Survival: <i>C. dubia</i> ≥95% - 48 hours</p> <p>Suspended Solids: <5.0 – 9.0 mg/L</p> <p>TRC: 0.01 – 0.08 mg/L</p> <p>pH: 6.9 - 7.4 SU</p> <p>Ammonia-nitrogen: <0.07 - 0.14 mg/L</p>	<p><u>EASTHAMPTON WWTP</u> – Outfall 001</p> <p>Data set: 5 tests June 1996 – December 1999</p> <p>LC₅₀: <i>C. dubia</i> 59.5% (Dec 1996) - > 100% effluent</p> <p>TRC: 0.05 - 0.16 mg/L</p> <p>Ammonia-nitrogen: 1.5 –7.0 mg/L</p>
<p><u>HOLYOKE WPCF</u> - mile marker #17 on Route 5</p> <p>Data set: 18 tests February 1996 – May 2000</p> <p>Survival: <i>C. dubia</i> ≥95% - 48 hours</p> <p>Suspended Solids: <1.0 – 22.0 mg/L</p> <p>TRC: <0.02 – 0.04 mg/L</p> <p>pH: 6.7 - 7.8 SU</p> <p>Ammonia-nitrogen: <0.03 - 0.21 mg/L</p> <p>Hardness: 25 - 37 mg/L</p>	<p><u>HOLYOKE WPCF</u> – in segment MA34-05</p>

Chemistry – water

Ambient water chemistry sample results were summarized for eight NPDES permitted facilities which submitted whole effluent toxicity reports to MA DEP DWM and discharge to this segment of the Connecticut River. Seventy sampling events were conducted between February 1996 and May 2000.

pH

The instream pH ranged from 6.1 to 7.9 SU. Two measurements were <6.5 SU.

Suspended Solids

Suspended solids ranged between <1.0 and 52 mg/L with one only measurement was above 25 mg/L.

Ammonia-Nitrogen

Ammonia-Nitrogen ranged from <0.01 to 17 mg/L. Two measurements exceeded the instream chronic water quality criterion of 1.46 mg/L using the highest documented pH (7.9 SU).

Total Residual Chlorine

TRC exceeded 0.05 mg/L in two samples with a high value of 0.08 mg/L.

Hardness

Hardness ranged from 22 to 76 mg/L.

Chemistry - tissue

Results of the USGS NAWQA study documented elevated levels of total PCB in whole fish at four sampling stations along the mainstem Connecticut River which exceeded the NAS/NAE

guidelines for the protection of fish-eating wildlife (Coles 1998). While this dataset however is limited to only one sample per station, the presence of PCB in fish throughout the entire mainstem Connecticut River (in MA), places the *Aquatic Life Use* on “Alert Status”.

The *Aquatic Life Use* is assessed as supported for the upper 28.5 miles based on the above instream water chemistry and toxicity data. The lower 5.7-mile reach (from Mt. Tom Power Station to the end of the segment at the Holyoke Dam) is not assessed due to discharges from multiple CSOs and power plants. PCB contamination has also been identified as an issue of concern (“Alert Status”) for this use.






Fish Consumption

MA DPH issued a fish consumption advisory for the Connecticut River (all towns between Northfield and Longmeadow), recommending that “Children younger than 12 years, pregnant women, and nursing mothers should not eat any fish from the Connecticut River and the general public should not consume channel catfish, white catfish, American eel, or yellow perch because of elevated levels of PCB (MA DPH 1999).

Data used to issue the fish consumption advisory for the Connecticut River (PCB contamination) are now approximately ten years old. As a result, questions as to whether contamination levels are better or worse today, or whether the levels of contamination are higher in the same fish species in different reaches of the river cannot be answered. A work plan for *Fish Tissue Testing in the Connecticut River* was developed by the Connecticut River Forum in 1999. Fish sampling for this project was initiated in 2000. This project is being managed by NEIWPC and US EPA NERL.

Because of the MA DPH fish consumption advisory, the entire 34.2 miles of this segment do not support the *Fish Consumption Use*.

Connecticut River (Segment MA34-04) Use Summary Table

Designated Uses		Status	Causes	Sources
Aquatic Life*		SUPPORT Upper 28.5 miles NOT ASSESSED Lower 5.7 miles		
Fish Consumption		NON SUPPORT	PCB contamination	Unknown
Primary Contact		NOT ASSESSED		
Secondary Contact		NOT ASSESSED		
Aesthetics		NOT ASSESSED		

* “**Alert Status**” issues identified – details in [Chemistry-tissue](#)

RECOMMENDATIONS Connecticut River (Segment MA34-04)

- Historically, elevated fecal coliform bacteria levels were documented in this segment of the Connecticut River. Monitoring of fecal coliform bacteria should be conducted under both wet and dry sampling conditions to evaluate the status of the *Primary* and *Secondary Contact Recreational* uses.
- Review the results of the *Fish Tissue Testing in the Connecticut River* study developed by the Connecticut River Forum in 1999.

Point source

- Sunderland Water District, Sunderland (1289000-02G) 1-06-289-05 is permitted to withdraw 0.24 MGD while their actual withdrawal volume is 0.34 MGD. This facility is currently under investigation by MA DEP's Drinking Water Program. Continue to monitor and evaluate the current and projected water use of this facility.
- Montague WPC (MA0100137) long-term concerns involve the development of a combined sewer overflow (CSO) control plan for the Town's one CSO on Greenfield Road. The facility has had past problems with filamentous bacteria. The facility accepts septage, however its septage receiving station needs to be upgraded. The permit expired midnight 29 September 2000 and should be reissued with appropriate limits and monitoring requirements.
- Bitzer Trout Hatchery permit (MA0110051) expired midnight 22 April 2000 and should be reissued with appropriate limits and monitoring requirements.
- B&M Railroad Yard permit (MA0000272) needs to be reissued with appropriate limits, stormwater runoff controls and monitoring requirements.
- Amherst WWTP permit (MA0100218) expires midnight 30 September 2000 and should be reissued with appropriate limits and monitoring requirements.
- South Deerfield WWTP (MA0101648) permit expires midnight 29 September 2000 and should be reissued with appropriate limits and monitoring requirements. Inflow and infiltration problems should be corrected.
- Sunderland WWTP (MA0101079) permit expired midnight 29 September 2000 and should be reissued with appropriate limits and monitoring requirements. A long-term sludge disposal method should be developed.
- Hatfield WWTP (MA0101290) permit expired midnight 29 September 2000 and should be reissued with appropriate limits and monitoring requirements. The town should pursue the removal of inflow and infiltration in its sewer system.
- Hadley WWTP (MA0100099) permit expired midnight 29 September 2000 and should be reissued with appropriate limits and monitoring requirements.
- Northampton WWTP (MA0101818) permit expired midnight 29 September 2000 and should be reissued with appropriate limits and monitoring requirements. Inflow and infiltration problems should be addressed.
- Easthampton WWTP (MA0101478) permit expired 29 October 2000 and should be reissued with appropriate limits and monitoring requirements.
- Northeast Utilities (MA0005339) – When the permit is reissued, EPA and MA DEP should consider including the # 2 fuel oil ground water remediation discharge now covered under an NPDES emergency exclusion; review conformance with the effluent guideline limits; and evaluate surface water/ ground water connections from the unlined settling basins. A 316 A & B analysis may be required during the next permit reissuance cycle (Keohane 2000). The permit should also be reissued with the following conditions: the high-pressure wash system

should be changed to have both low and high pressure; chlorination should occur downstream of the screens; and there should be a fish return (Szal 2000).

- One particular issue of concern related to this facility is the use of chlorine to control biofouling in steam condenser tubes. Shortnose sturgeon, a federally endangered species, are reportedly attracted to thermal plumes and are also believed to be extremely sensitive to chlorine. The facility chlorinates once per day for two hours. Sensitive life stages of the sturgeon may be utilizing the heated discharge plume as preferred habitat in the winter, and may be exposed to pulses of chlorine that may have a negative effect on them. Furthermore higher temperatures increase the metabolic rates of cold-blooded animals and would exacerbate the negative effects of chlorine. If sturgeon or other fish are preferentially using the thermal plume, dechlorination should be considered. Studies designed to 1) characterize the species utilizing the thermal plume as habitat throughout the year, 2) to evaluate entrainment and impingement effects and 3) reevaluate the thermal plume should also be considered (Szal 2000).

Combined Sewer Overflows:

- Holyoke will be required to implement “9 Minimum Controls” as a condition of their new NPDES permit as well as to develop a long-range control plan to address abatement of impacts related to CSOs (Hogan 2000). Holyoke’s four overflows upstream of the Dam are of significant concern to MA DEP. Since swimming areas have been identified in the Facilities Plan and MA DFWELE has also raised concerns about impacts to fish passage at and near the Dam, MA DEP and EPA will scrutinize CSO controls very carefully in this area as a result. Depending on the results of the Final CSO plan, the SWQS will need to be updated. If any CSO discharges are to remain, then a B (CSO) designation would be necessary (Brander 2000).

The following is excerpted from the full Merrimack River Watershed Assessment, available on the Web at <http://www.mass.gov/dep/brp/wm/wqassess.htm> .

Executive Summary

MERRIMACK RIVER BASIN 1999 WATER QUALITY ASSESSMENT REPORT

The Merrimack River is the fourth largest watershed in New England with a total drainage area of 5,010 square miles, with 24 percent, or 1,200 square miles, in Massachusetts. The main branch of the Merrimack is formed in central New Hampshire by the confluence of the Pemigewasset and Winnepesaukee Rivers. The river flows south through central New Hampshire for 78 miles and into Massachusetts. Once in Massachusetts, it continues generally southeast for about 6 miles before turning to the northeast, near the City of Lowell. From here, the Merrimack flows its remaining 44 miles to the City of Newburyport where it empties into the Atlantic Ocean. Within Massachusetts there are 50 miles of mainstem river habitat, the lower 22 miles of which is tidal, and most of the remaining habitat is impounded by two major hydroelectric dams, one at Lawrence and one at Lowell.

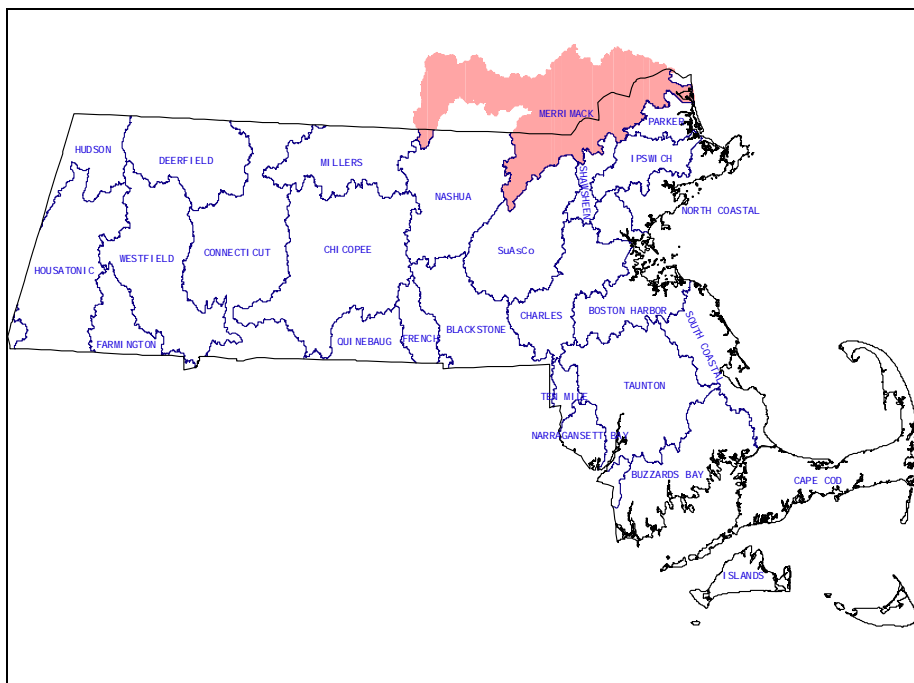


Figure 22: Lower Merrimack River Basin Drainage Area.

The Massachusetts Surface Water Quality Standards (SWQS) designate the most sensitive uses for which surface waters in the Commonwealth shall be protected. The Massachusetts Department of Environmental Protection (MA DEP) is responsible for the assessment of current water quality conditions, which is a key step in the successful implementation of the Massachusetts Watershed Approach. This critical phase provides an assessment of whether or not the designated uses are being met (support, partial support, non-support) or are not assessed, as well as basic information needed to focus resource protection and remediation activities later in the watershed management planning process.

This assessment report presents a summary of current water quality data/information in the Massachusetts portion of the Merrimack River Basin (exclusive of the Nashua, Concord and Shawsheen River basins) used to assess the status of the designated uses as defined in the SWQS. Each use, within a given segment, is individually assessed as 1) **support**, 2) **partial support**, or 3) **non-support**. When too little current data/information exists or no reliable data are available the use is **not assessed**. However, if there is some indication of water quality impairment, which is not “naturally occurring”, the use is identified with an “Alert Status”. It is important to note that not all waters are assessed. Many small and/or unnamed rivers and ponds are currently **unassessed**; the status of their designated uses has never been reported to the United States Environmental Protection Agency (EPA) in the Commonwealth’s 305(b) Report nor is information on these waters maintained in the Waterbody System (WBS) database.

There are a total of 19 freshwater rivers, streams, brooks or creeks (the term “rivers” will hereafter be used to include all) assessed in this report. These include: the mainstem Merrimack River, Martins Pond Brook (in the Salmon Brook subwatershed, which joins the mainstem in New Hampshire), Beaver and Stony brooks and an unnamed tributary locally known as “Reedy Meadow Brook” in the Stony Brook subwatershed, and the following direct tributaries to the mainstem river (upstream to downstream): Lawrence, Deep, Black, Beaver, Trull (and its Trout Brook tributary), and Richardson brooks, the Spicket River, Bare Meadow Brook, Little River, Johnson Creek, Cobbler Brook, and the Powwow River (including the Back River). Three estuarine areas, including the tidally-influenced mainstem Merrimack, Powwow, and Plum Island rivers, and 27 lakes, ponds or impoundments (the terms “lakes will hereafter be used to include all) in the Merrimack River Basin are also included in this report. These assessments represent approximately 24% of the 79 named streams and 46% (104.49) of the estimated 225.1 river miles in the basin. The remaining rivers are small and/or unnamed, and they are currently unassessed. Nearly all of the estuarine area is assessed, as are 28% of the 96 lakes, comprising 70% (3,375 out of 4,803) of the lake acreage. Ten of the lakes, representing 2,047 acres, are Class A public water supplies.

The status of the designated uses for these waterbodies is summarized in a segment format, which includes 25 river segments, five estuarine segments, and 27 lake segments. The designated uses, where applicable, include: *Aquatic Life*, *Fish Consumption*, *Drinking Water*, *Shellfishing*, *Primary* and *Secondary Contact Recreation* and *Aesthetics*.

AQUATIC LIFE USE – RIVERS, ESTUARIES, AND LAKES

The *Aquatic Life Use* is supported when suitable habitat (including water quality) is available for sustaining a native, naturally diverse, community of aquatic flora and fauna. Impairment of the

Aquatic Life Use (non-support or partial support) may result from anthropogenic stressors that include point and/or nonpoint source(s) of pollution and hydrologic modification.

The status of the *Aquatic Life Use* in the Merrimack River Basin can be summarized as follows:

Rivers (miles)	Estuaries (square miles)	Lakes (acres)
5.9 miles SUPPORT 36.9 miles PARTIAL SUPPORT 1.1 miles NON-SUPPORT 60.59 miles NOT ASSESSED	6.97 square miles PARTIAL SUPPORT 0.35 square miles NOT ASSESSED	534 acres PARTIAL SUPPORT 2841 acres NOT ASSESSED

...[O]f the 104.49 river miles in the Merrimack River Basin included in this report, a total of only 5.9 river miles (approximately 6%) are assessed as supporting the *Aquatic Life Use*. These include the upper portions of only two streams (Stony Brook and the Spicket River) and the entire length of an unnamed tributary (locally known as “Reedy Meadow Brook”). The *Aquatic Life Use* was assessed as impaired (partial or non-support) for 36% of the river miles while the majority (58%) of the river miles in the basin included in this report are currently not assessed for the *Aquatic Life Use*.

A total of 36.9 river miles (portions or all of five streams) are assessed as partial support for the *Aquatic Life Use* The lower 8.5-miles of Stony Brook are impaired (partial support) as a result of moderate enrichment, but habitat quality degradation (sedimentation, low-flow conditions) is also suspected as a cause of impairment. One mile within this reach is also threatened by toxicity from an industrial discharge. The lower 3.8-mile reach of the Spicket River is also impaired (partial support) due to habitat alteration/modification and channelization, as well as urban runoff. Severe habitat degradation (sedimentation, trash and debris) adversely impacts Beaver Brook in Dracut. Although the cause of impairment (partial support 4.5 miles) in Cobbler Brook is unknown, organic enrichment, riparian disturbances, seasonal low-flow conditions, and flow alteration resulting from impoundment(s) are suspected. The *Aquatic Life Use* for the lower 15.9-mile reach of the freshwater portion of the mainstem Merrimack River (from Duck Island, Lowell to the confluence with Creek Brook in Haverhill), as well as the estuarine portion of the Merrimack River (6.97 square miles), is assessed as partial support because of elevated concentrations of total polychlorinated biphenyls (PCB) in whole fish samples (as opposed to edible fillets) collected from the Merrimack River downstream from Duck Island in Lowell. The PCB concentrations exceed the National Academy of Sciences/National Academy of Engineers (NAS/NAE) guideline for the protection of fish-eating wildlife. Source(s) of total PCB are unknown at this time and warrant further investigation.

Habitat/flow alteration impairs (non-support) the *Aquatic Life Use* for a total of 1.1 river miles in the Merrimack River Basin There is a 0.7-mile reach of Merrimack River streambed (downstream from the Pawtucket Dam through Pawtucket Falls to the confluence with the Lowell Project tailrace) exposed as a result of hydromodification (flow is periodically diverted solely through the Northern canal system). Habitat quality is also impaired in the lower 0.4-mile reach of the Little River because of channel alteration (the river is culverted underground).

The majority of the lakes in the Merrimack River Basin (22 lakes representing 2,841 acres) are not assessed for the *Aquatic Life Use*. Five lakes, however, representing 16% of the lake acreage, are infested with non-native aquatic vegetation and are, therefore, assessed as impaired (partial

support) for the *Aquatic Life Use* The non-native aquatic vegetation includes the following: *Myriophyllum heterophyllum* (variable milfoil) found in Flint, Massapoag, and Spectacle ponds and Knops Pond/Lost Lake; *Cabomba caroliniana* (fanwort) found in Knops Pond/Lost Lake, Newfield and Spectacle ponds; *Potamogeton crispus* (curly-leaf pondweed) found in Newfield, Massapoag, and Spectacle ponds; *Najas minor* (European naiad) found in Flint Pond and *Myriophyllum spicatum* (Eurasian milfoil) found in Newfield Pond. These five non-native aquatic plant species are particularly invasive and reproduce vegetatively; therefore, they may spread readily downstream on currents or between lakes by mechanical transport.

Oxygen depletion in the hypolimnion (summer surveys) was another cause of partial support that was documented in Massapoag, Newfield and Spectacle ponds. This oxygen depletion is presumably the result of organic enrichment.

While not an indicator used to assess the status of the *Aquatic Life Use*, estimates of trophic status of the lakes in the Merrimack River Basin are summarized below.

Estimates of trophic status for lakes in the Merrimack River Basin.

TROPHIC STATUS	NUMBER OF PONDS	ACRES
Eutrophic	6	703
Hypereutrophic	3	95
Undetermined*	18	2,577
Total	27	3,375

* It should be noted that some lakes or portions of lakes are listed as undetermined when indicators were not readily observable. With this approach, only the most obvious impairments are reported and, therefore, the assessment of lakes in the Merrimack River Basin is limited to a "best case" picture. Potentially more of the lake acreage would be listed as impaired, or in a more enriched trophic status, if more variables were measured and more criteria assessed.

FISH CONSUMPTION USE – RIVERS, ESTUARIES AND LAKES

The *Fish Consumption Use* is supported when there are no pollutants present that result in unacceptable concentrations in edible portions (as opposed to whole fish - see *Aquatic Life Use*) of marketable fish or for the recreational use of fish, other aquatic life or wildlife for human consumption. The assessment of the *Fish Consumption Use* is made using the most recent list of Fish Consumption Advisories issued by the Massachusetts Executive Office of Health and Human Services, Department of Public Health (MDPH), Bureau of Environmental Health Assessment (MDPH 2001a). The MDPH list identifies waterbodies where elevated levels of a specified contaminant in edible portions of freshwater species poses a health risk for human consumption; hence the *Fish Consumption Use* is assessed as non-support in these waters. In July 2001, MDPH issued new (updated from 1994) consumer advisories on fish consumption and mercury contamination (MDPH 2001b). Because of the statewide advisories, no waters can be assessed as either support or partial support for the *Fish Consumption Use*. The statewide advisories read as follows:

The MDPH “is advising pregnant women, women of childbearing age who may become pregnant, nursing mothers and children under 12 years of age to refrain from eating the following marine fish; shark, swordfish, king mackerel, tuna steak and tilefish. In addition, MDPH is expanding its previously issued statewide fish consumption advisory which cautioned pregnant women to avoid eating fish from all freshwater bodies due to concerns about mercury contamination, to now include women of childbearing age who may become pregnant, nursing mothers and children under 12 years of age (MDPH 2001b).”

Additionally, MDPH “is recommending that pregnant women, women of childbearing age who may become pregnant, nursing mothers and children under 12 years of age limit their consumption of fish not covered by existing advisories to no more than 12 ounces (or about 2 meals) of cooked or uncooked fish per week. This recommendation includes canned tuna, the consumption of which should be limited to 2 cans per week. Very small children, including toddlers, should eat less. Consumers may wish to choose to eat light tuna rather than white or chunk white tuna, the latter of which may have higher levels of mercury (MDPH 2001b).” MDPH’s statewide advisory does not include fish stocked by the state Division of Fisheries and Wildlife or farm-raised fish sold commercially.

Recent investigations by the United States Geological Survey (USGS) including their National Mercury Pilot Study, New England Coastal Basin (NECB) Mercury Study, Toxics Substances Hydrology Program, and Urban Land Use Gradient Study showed some of the highest mercury concentrations in the country were in the NECB study area. The dominant source of mercury identified in the NECB study area was atmospheric deposition. A directed study of fish in lakes in northeastern Massachusetts, the MA DEP Merrimack Valley Fish Study, was also recently performed by the MA DEP Office of Research and Standards (ORS) to examine possible spatial patterns in the occurrence of higher fish mercury concentrations and to compare the fish contamination situation in this localized geographical region to state wide and regional data. This region was recently identified through the use of an air deposition model as having the highest predicted annual levels of recent wet and dry atmospheric deposition of mercury in the state. The area has the state’s largest concentration of point sources of atmospheric mercury emissions: three municipal solid waste incinerators and a medical waste incinerator. While historic records of atmospheric mercury deposition in this area do not exist, past widespread burning of coal for domestic heat and industrial boilers in the late nineteenth and first half of the twentieth centuries probably contributed to a relatively high background mercury signature in the environment of this part of the state.

Because of elevated levels of mercury in edible portions of fish, the status of the *Fish Consumption Use* in the Merrimack River Basin is as follows:

Fish Consumption Use Summary

Rivers (miles)	Estuaries (square miles)	Lakes (acres)
20.8 miles NON-SUPPORT	7.32 square miles NOT ASSESSED	2,583 acres NON-SUPPORT
83.69 miles NOT ASSESSED		792 acres NOT ASSESSED

MDPH has issued an advisory for the mainstem Merrimack River for all towns between Tyngsborough and Methuen (MDPH 2001a). The *Fish Consumption Use* is, therefore, assessed as non-support for a total of 20.8 miles from the MA/NH state line to the Essex Dam in Lawrence Because of the statewide advisory, the use is not assessed for the remaining 83.69 riverine miles or the 7.32 square mile estuarine area. MDPH has also issued fish consumption advisories for 17 lakes in the Merrimack River Basin because of health concerns related to mercury. These waterbodies include: Attitash, Cochichewick, Pentucket, Saltonstall, Crystal,

Kenoza and Forest lakes; Chadwick, Haggets, Hoveys, Johnsons, Flint, Long, Newfield, Masspoag and Stevens ponds; and Millvale Reservoir (MDPH 2001a). The *Fish Consumption Use* is, therefore, assessed as non-support for these lakes, a total of 2,583 acres. Ten of these lakes, totaling 2,047 acres, are Class A public water supplies. The remaining 792 lake acres (10 lakes) in the Merrimack River Basin are not assessed for this use.

DRINKING WATER USE – RIVERS AND LAKES

The term *Drinking Water Use* has been used to indicate sources of public drinking water. While this use is not assessed in this report, information on drinking water source protection and finish water quality is available at <http://www.state.ma.us/dep/brp/dws/dwshome.htm> and from the Merrimack River Basin public water suppliers. These waters are subject to stringent regulation in accordance with the Massachusetts Drinking Water Regulations. MA DEP's Drinking Water Program (DWP) has primacy for implementing the provisions of the federal Safe Drinking Water Act. DWP has also initiated work on its Source Water Assessment Program (SWAP), which requires that the Commonwealth delineate protection areas for all public ground and surface water sources, inventory land uses in these areas that may present potential threats to drinking water quality, determine the susceptibility of water supplies to contamination from these sources, and publicize the results. Except for suppliers with surface water sources for which a waiver from filtration has been granted (these systems also monitor surface water quality), public water suppliers monitor their finished water (tap water) for major categories of contaminants (e.g., bacteria, volatile and synthetic organic compounds, inorganic compounds, etc.) and report their data to DWP.

SHELLFISHING USE – ESTUARIES

The *Shellfishing Use* is supported when shellfish harvested from approved Open Shellfish Areas (Class SA) are suitable for consumption without depuration and shellfish harvested from approved Restricted Shellfish Areas (Class SB) are suitable for consumption with depuration. The Division of Marine Fisheries (DMF) classifies the shellfishing areas in the Merrimack River Basin. The *Shellfishing Use* for this report was assessed using the DMF shellfishing closure list dated October 2000 (DFWELE 2000). The status of the 2,948.402 acres of shellfishing beds in the Merrimack River Basin (including areas that extend into open-water and areas not specifically included in this assessment report) is as follows:

DMF Classification Type	MA DEP Use Support Status	DMF Area (acres)	% of total DMF acreage
Approved	Support	179.403	6%
Conditionally Approved	Partial support	0	0%
Prohibited	Non-support	2,768.999	94%

PRIMARY AND SECONDARY CONTACT RECREATIONAL USE – RIVERS, ESTUARIES, AND LAKES

The *Primary Contact Recreational Use* is supported when conditions are suitable (fecal coliform bacteria densities, pH, temperature, turbidity and aesthetics meet the Surface Water Quality Standards) for any recreational or other water related activity during which there is prolonged

and intimate contact with the water with a significant risk of ingestion. Activities include, but are not limited to, wading, swimming, diving, surfing and water skiing. The *Secondary Contact Recreational Use* is supported when conditions are suitable for any recreational or other water use during which contact with the water is either incidental or accidental. These include, but are not limited to, fishing, boating and limited contact incident to shoreline activities. For lakes, macrophyte cover and/or transparency (Secchi disk depth) data are assessed to evaluate the status of the recreational uses.

The status of the *Primary Contact Recreational* uses in the Merrimack River Basin is as follows:

Rivers (miles)	Estuaries (square miles)	Lakes (acres)
8.9 miles NON-SUPPORT	4.67 square miles SUPPORT	167 acres NON-SUPPORT
95.59 miles NOT ASSESSED	2.65 square miles NOT ASSESSED	3208 acres NOT ASSESSED

The status of the *Secondary Contact Recreational* uses in the Merrimack River Basin is as follows:

Rivers (miles)	Estuaries (square miles)	Lakes (acres)
4.7 miles NON-SUPPORT	4.67 square miles SUPPORT	163 acres SUPPORT
99.79 miles NOT ASSESSED	2.65 square miles NOT ASSESSED	167 acres NON-SUPPORT
		3045 acres NOT ASSESSED

...[T]he majority (91%) of the river miles in the Merrimack River Basin are not assessed for the *Primary Contact Recreational Use*. Because of the periodic public beach closures at the Lowell Heritage State Park, 4.2 miles of the mainstem Merrimack River are impaired (non-support) for the *Primary Contact Recreational Use*. This portion of the Merrimack River, however, is not assessed for the *Secondary Contact Recreational Use*. As a result of degraded aesthetic quality conditions and/or combined sewer overflow (CSO) discharges, portions of three tributaries to the Merrimack River are impaired (non-support) for both the *Primary* and *Secondary Contact Recreational* uses. These include a half-mile reach of Beaver Brook affected by objectionable deposits, turbidity, and oil from CSO discharges and illegal dumping, a 3.8-mile reach of the Spicket River because of urban runoff, and a 0.4-mile reach of the Little River as result of elevated bacteria levels from CSO discharges. Fecal coliform bacteria data collected by the DMF Shellfish Sanitation Program were used to determine that a total of 64% of the estuarine area (east of the Route 95 bridge) in the Merrimack River Basin supports the *Primary* and *Secondary Contact Recreational* uses. The estuarine areas west of the Route 95 bridge (including a portion of the mainstem Merrimack River and the Powwow River are currently not assessed for the recreational uses (DMF does not sample upstream of the bridge).

Few lakes in the Merrimack River Basin have recently been surveyed for variables used to assess the status of the recreational uses (i.e., bacteria data, macrophyte cover, transparency). As a result, the majority (over 90%) of the lake acreage is not assessed for the *Primary* and *Secondary Contact Recreational* uses. The recreational uses are, however, assessed as impaired (non-support) in 167 acres (portions of Flint, Massapoag, Newfield and Spectacle ponds) because of very dense macrophyte cover. The *Secondary Contact Recreational Use* is assessed as support for a total of 163 acres (the “open-water” acreage) in these four waterbodies.

AESTHETICS USE – RIVERS, ESTUARIES, AND LAKES

The *Aesthetics Use* is supported when surface waters are free from pollutants in concentrations or combinations that settle to form objectionable deposits; float as debris, scum or other matter to form nuisances; produce objectionable odor, color, taste or turbidity; or produce undesirable or nuisance species of aquatic life.

The status of the *Aesthetics Use* in the Merrimack River Basin is as follows:

Rivers (miles)	Estuaries (square miles)	Lakes (acres)
30.5 miles SUPPORT	7.27 square miles SUPPORT	163 acres SUPPORT
9.2 miles NON-SUPPORT	0.05 square miles NOT ASSESSED	167 acres NON SUPPORT
64.79 miles NOT ASSESSED		3095 acres NOT ASSESSED

...[M]any of the tributaries to the Merrimack River are not assessed for the *Aesthetics Use*. The *Aesthetics Use* is impaired (non-support) in portions or all of four tributaries (Beaver Brook, Spicket and Little rivers, and Cobbler Brook) as a result of objectionable deposits, odor, oils and/or turbidity resulting from urban runoff, illegal dumping and combined sewer overflows. The entire mainstem and estuarine portion of the Merrimack River, however, is aesthetically acceptable and, therefore, assessed as support for the *Aesthetics Use*. The estuarine area of the Powwow River (0.05 square miles) was not assessed for the *Aesthetics Use*.

The majority of the lake acreage (92%) in the Merrimack River Basin is currently not assessed for the *Aesthetics Use*. The “open-water” acreage (a total of 163 acres) of Flint, Massapoag, Newfield and Spectacle ponds, is assessed as support for the *Aesthetics Use*, however, the dense/very dense macrophyte cover along the shorelines of Massapoag, Newfield and Spectacle ponds (a total of 167 acres) impairs (non-support) the *Aesthetic Use*.

RECOMMENDATIONS – RIVERS, ESTUARIES AND LAKES

In addition to specific issues for the individual segments, the evaluation of current water quality conditions in the Merrimack River Basin has revealed the need for the following:

- Conduct additional monitoring (e.g., passive water column PCB samplers, whole fish tissue), to determine the extent, and if necessary, source(s) of PCB contamination along the mainstem Merrimack River. Determine locations of current and historical sources of PCB in the River and in its tributaries.
- Conduct biological and water quality monitoring to evaluate the effects of National Pollutant Discharge Elimination System (NPDES) permittees, power plants, CSOs and nonpoint sources of pollution and to document any changes in water quality conditions as a result of infrastructure improvements/pollution abatement controls.
- Evaluate the CSO Control Plans for Lowell Regional Water and Wastewater Utilities, Greater Lawrence Sanitary District, and the Haverhill Water Pollution Control Facility, and, when approved, require that they implement CSO controls expeditiously to address these known sources of pollution.
- Develop and reissue NPDES permits for surface water discharges in the Merrimack River Basin. If dischargers in the Basin have problems meeting their whole effluent toxicity limits,

the need for a toxicity identification evaluation/toxicity reduction evaluation (TIE/TRE) may be warranted.

- As part of the Water Management Act (WMA) 5-year review process, MA DEP should continue to evaluate compliance with registration and/or permit limits for suppliers in the Merrimack River Basin. Work with water suppliers to optimize water withdrawal and reservoir management practices to maintain minimum streamflow.
- Habitat quality evaluations should be conducted along streams/rivers to assess streamflow conditions as related to water withdrawals and/or flow management practices (e.g., outlet control operations). Collect additional data, where necessary, to determine the frequency, duration, and spatial extent of the low flow conditions.
- Habitat quality evaluations should be conducted along streams/rivers to document areas of erosion and sedimentation. Develop and implement best management practices (BMPs) to control storm water runoff.
- Work with the Division of Marine Fisheries, Coastal Zone Management and local communities to identify and reduce sources of contamination (e.g., storm water, failing septic systems, etc.) to shellfish areas.
- Work with the Merrimack River Watershed Council to identify causes and sources of contamination, conduct stream cleanups, and encourage/strengthen local stewardship and with the Stream Teams to implement their priority actions.
- When the MA DEP Drinking Water Program SWAP evaluations are completed, develop and implement recommendations to protect the Class A rivers and lakes in the Merrimack River Basin.
- Coordinate with the MA Department of Environmental Management (MA DEM) and/or other groups conducting lake and watershed surveys to generate quality assured lakes data. As part of any lake water quality evaluation, include identification of non-native species and mapping of macrophyte cover in order to evaluate the status of the *Aquatic Life*, *Recreational* and *Aesthetic* uses.
- Review data from “Beaches Bill” required water quality testing (bacteria sampling at all formal bathing beaches) to assess the status of the recreational uses.
- Review recommendations for long-term restoration/preservation from lake diagnostic/feasibility studies and watershed management plans and effect their implementation. Implement recommendations from the nutrient total maximum daily load (TMDL) analysis currently being prepared by MA DEP.
- Monitor and control the spread and growth of exotic aquatic and wetland vegetation. Determine the effectiveness of the herbicide treatment on the non-native, aquatic plant infestations. Prevent the further spread of these plants to unaffected areas (of this pond and to other ponds) by alerting pond-users to the problem and responsibility of spreading these exotic species. This should include posting of boat access points with educational warning signs.

Species of Greatest Conservation Need in the Connecticut and Merrimack Mainstems

State Listing Status	Taxon Grouping	Scientific Name	Common Name	State Status
State-listed	Fishes	<i>Acipenser brevirostrum</i>	Shortnose Sturgeon	E
		<i>Acipenser oxyrinchus</i>	Atlantic Sturgeon	E
		<i>Hybognathus regius</i>	Eastern Silvery Minnow	SC
		<i>Lota lota</i>	Burbot	SC
	Birds	<i>Haliaeetus leucocephalus</i>	Bald Eagle	E
	Mussels	<i>Alasmidonta undulata</i>	Triangle Floater	SC
		<i>Lampsilis cariosa</i>	Yellow Lampmussel	E
		<i>Leptodea ochracea</i>	Tidewater Mucket	SC
		<i>Ligumia nasuta</i>	Eastern Pondmussel	SC
		<i>Strophitus undulatus</i>	Creeper	SC
	Odonates	<i>Gomphus fraternus</i>	Midland Clubtail	E
		<i>Gomphus quadricolor</i>	Rapids Clubtail	T
		<i>Gomphus vastus</i>	Cobra Clubtail	SC
		<i>Gomphus ventricosus</i>	Skillet Clubtail	SC
		<i>Neurocordulia obsoleta</i>	Umber Shadowdragon	SC
		<i>Neurocordulia yamaskanensis</i>	Stygian Shadowdragon	SC
		<i>Stylurus amnicola</i>	Riverine Clubtail	E
		<i>Stylurus spiniceps</i>	Arrow Clubtail	T
	Beetles	<i>Cicindela marginipennis</i>	Cobblestone Tiger Beetle	E
		<i>Cicindela puritana</i>	Puritan Tiger Beetle	E
Not Listed	Fishes	<i>Alosa aestivalis</i>	Blueback Herring	--
		<i>Alosa pseudoharengus</i>	Alewife	--
		<i>Alosa sapidissima</i>	American Shad	--
		<i>Anguilla rostrata</i>	American Eel	--
		<i>Catostomus commersoni</i>	White Sucker	--
		<i>Luxilus cornutus</i>	Common Shiner	--
		<i>Petromyzon marinus</i>	Sea Lamprey	--
		<i>Salmo salar</i>	Atlantic Salmon	--
		<i>Semotilus corporalis</i>	Fallfish	--

Although classified as an anadromous fish, the Shortnose Sturgeon is almost never found in the open ocean. Instead, individuals spend their lives in the mainstem river undergoing migrations between discrete spawning, rearing, and feeding areas — including the estuary. Spawning occurs in the spring in rapidly moving sections of the mainstem rivers — now found only below dams. Atlantic Sturgeon are anadromous, entering large freshwater river systems to spawn during the spring. While there are no spawning populations of the Atlantic Sturgeon in Massachusetts, juvenile Atlantic Sturgeon can occasionally be found in the estuaries and lower portions of the major rivers during the summer months.

In Massachusetts, Eastern Silvery Minnows are found currently only in the Connecticut River above the Holyoke Dam. Once more common in this river, the population has apparently declined over the past few decades, possibly because of changes in river flows due to dams. Similarly, the Burbot in Massachusetts is found only in the Connecticut River. Very few Burbot have even been found in the Massachusetts stretch of the Connecticut and it is unclear what the status of this population is in Massachusetts.

Several pairs of Bald Eagle nest along the Connecticut and Merrimack Rivers. The first pair of nesting Bald Eagles along the Merrimack in recent years only took up residence in 2004. Both the Connecticut and Merrimack are used for summer feeding, migration, and over-wintering by all age classes of Bald Eagle.

Five species of rare freshwater mussel are found in these mainstem rivers. In Massachusetts, the Yellow Lampmussel is found only in the Connecticut River, in very small numbers. Historically, it was also in the Merrimack River, but there have been no recent sightings of this mussel there. Only one live Tidewater Mucket has ever been found in these mainstems, in the Connecticut; normally this species is found in ponds and lakes. The other three mussels (Triangle Floater, Brook Floater, and Creeper) are much more common in the Connecticut River than in the Merrimack.

Similarly, the Connecticut River was thought to support many more rare dragonfly species than the Merrimack River, but the Cobra Clubtail, Umber Shadowdragon, Riverine Clubtail, and Arrow Clubtail were recently discovered on the Merrimack during surveys in 2004, illustrating the need for more surveys for rare riverine odonates on these two rivers.

The Connecticut River supports the only populations of the Cobblestone and Puritan Tiger Beetles in Massachusetts. It is quite unlikely that these species could be found on the Merrimack in Massachusetts. Both beetles use bars of sorted substrate (cobbles and sand, respectively) along the river's edge, and are highly susceptible to alterations in river flows, as well as human use of river banks.

Both the Connecticut and Merrimack Rivers support Sea Lamprey populations. The tributaries of these rivers are critical habitat for this species. Sea Lampreys are anadromous, migrating from the ocean to freshwater specifically to reproduce. Adult lampreys are parasitic, attaching themselves to a variety of oceanic fish species and feeding on their blood and body fluids. After two years at sea, lampreys enter rivers in the spring, mid-April through June in the Connecticut and Merrimack Rivers. Spawning occurs in the tributaries in the early summer. Lampreys build shallow nests in the gravel bottom, deposit their eggs, and then die. Fertilized eggs hatch in about two weeks and the young (known as ammocoetes) drift with the current until they find suitable soft substrate where they burrow into the stream bottom and live as filter feeders for four to five years. Eventually ammocoetes transform into young adults that migrate to the ocean.

The Connecticut and Merrimack Rivers each support viable American Shad populations below the first mainstem dam on each river. The mainstem portions of these rivers are critical habitat for this species. American Shad are anadromous, migrating from the ocean to freshwater specifically to reproduce. Adult shad enter rivers in the spring, mid-April through June in the Connecticut and Merrimack. Spawning occurs in the mainstem rivers and their larger tributaries in the early summer. Spawning usually occurs over gently sloping areas with fine gravel or sandy bottoms. After spawning, adult shad return to the sea. Fertilized eggs are carried by river currents and hatch within a few days. Larvae drift with the current until they mature into juveniles which remain in nursery areas (mainstem rivers and their larger tributaries), feeding on zooplankton and terrestrial insects. By late fall, most juvenile shad migrate to near-shore coastal

wintering areas. Some juvenile shad will remain in mainstem rivers and estuaries up to a year before entering the ocean.

The Connecticut and Merrimack Rivers each support river herring (Alewife and Blueback Herring) populations. The mainstem portions of these rivers are critical habitat for these species. River herring spawn in mainstem rivers and tributaries from April to mid-July when water temperatures range from 51° (Alewife) or 57° (Blueback Herring) to 81° F. Upstream distribution of adults is a function of habitat suitability and hydrologic conditions permitting access to these sites. Immediately after spawning, surviving adult river herring migrate rapidly downstream to return to the sea. Alewives are still-water spawners and focus their reproductive efforts in the tidal portions of the rivers. In addition to the mainstem, alewives also use spawning habitat in backwaters and impoundments. Spawning can occur over a range of substrates such as gravel, sand, detritus, and submerged vegetation. Blueback Herring spawning sites include swift flowing sections of freshwater rivers, channel sections of fresh and brackish tidal rivers, and Atlantic coastal ponds over gravel and clean sand substrates. Blueback Herring in the Connecticut River basin migrate farther upstream in the mainstem (to Bellows Falls, Vermont) than do Alewives. Juvenile river herring occur in non-tidal and tidal freshwater and semi-brackish areas (mainstems and major tributaries) during spring and early summer, moving upstream during periods of decreased flows and encroachment of saline waters. Juveniles begin migrating from their nursery areas to the sea in the fall, cued by heavy rainfalls, high waters, or sharp declines in water temperatures.

The American Eel is a catadromous species, which spends most of its life in rivers, lakes and estuaries, but migrates to the ocean to spawn. Populations of American Eel occur in both the Connecticut and Merrimack Rivers. The mainstem portions of these rivers are an important migratory route, but also serve as the primary rearing habitat for some portion of the population. Some eels remain in the estuaries, but others migrate varying distances upstream, often for several hundred kilometers. American Eels will remain in the brackish and fresh waters of these rivers for the majority of their lives – for at least five and possibly as many as twenty years. Mature eels migrate back to the waters of the Sargasso Sea to spawn. The migration occurs throughout autumn nights with adults descending streams and rivers to the estuaries for January spawning in the warm Caribbean waters.

The Atlantic Salmon was extirpated from Massachusetts early in the 19th century, but restoration efforts are underway on both the Connecticut and Merrimack Rivers. All Atlantic Salmon spawning and rearing habitat is found in the tributaries, but the mainstem rivers serve as vital migratory corridors to and from these habitats. Atlantic Salmon are anadromous, migrating from the ocean to freshwater specifically to reproduce. Adults enter the rivers in the spring (April-June) and quickly migrate upstream and into tributaries. After spawning in the fall, the surviving adults will either migrate downstream to the sea immediately or spend the winter in river before returning to the sea in the spring. Two-year-old juvenile Atlantic salmon, known as smolts, undertake a migration to the sea in the spring. This migration from tributary, to mainstem, to estuary may take as long as three months for individuals migrating from far up in the watershed. This protracted migration period results in salmon smolts being present in the mainstem throughout the spring (April- June).

Threats to Connecticut and Merrimack Mainstems

Water Quality Threats: Threats include specific locations of problems such as toxins in the rivers (e.g., PCBs), combined sewer overflows (CSOs), bio-accumulation of contaminants, and non-point source pollution, such as agricultural runoff. CSOs in Massachusetts regularly cause temporary Class C water quality conditions in urban areas after storm events.

Habitat Loss and Fragmentation: Impoundment, filling of wetlands bordering the rivers, and urbanization of the river corridor lead to habitat loss and fragmentation. Disconnection of the rivers from their floodplains by channelization has led to dramatic changes in habitat.

Air Pollution: Acid precipitation and atmospheric deposition of mercury and other contaminants are a problem throughout the Northeast. While some sources are local, most sources of air pollution affecting our rivers are outside the region.

Hydroelectric Dams: The Connecticut and Merrimack are some of the most developed rivers in the Northeast. The Massachusetts sections of each of these rivers contain two major hydroelectric dams — including the first dam upstream from the sea on each system. These large dams with operating hydroelectric facilities create unique threats to fish and wildlife populations:

- **Impoundment** — About one-third of the mainstem Connecticut River and most of the freshwater habitat of the Merrimack River in Massachusetts are impounded. The habitat found in these impoundments is far different from that of free-flowing rivers.
- **Bypass** — Large hydroelectric projects were built at the sites of natural features conducive to water power, e.g., at natural falls. On the Connecticut River, the Hadley Falls and the Turners Falls are now the sites of major dams which divert much of the river flow away from the rapids habitat below. In fact, the former rapids below both the Turners Falls dam on the Connecticut and the Pawtucket dam on the Merrimack are dry for much of the summer.
- **Population fragmentation** — Dams form barriers to migration, which can dramatically reduce the habitat available to anadromous fish and may fragment resident fish populations. This reduction in fish migration also affects freshwater mussels, whose larvae are parasitic on fish. Mussels can disperse over long distances only by means of their fish hosts.
- **Flow alteration** — The Turners Falls Hydroelectric Project on the Connecticut River is a “peaking” project. It stores water over a period of several hours, then releases it all at once, dramatically changing the river flow. These daily changes in flow below the dam and reservoir level above the dam disrupt fish and wildlife habitat and lead to large-scale riverbank erosion.

Invasive Species: A number of invasive species have taken hold in these watersheds and threaten native species. These include: Common Reed (*Phragmites*), Purple Loosestrife, Eurasian Milfoil, and Water Chestnut, as well as Mute Swans, Asiatic Clams, and Woolly Adelgid. Fortunately, neither the Connecticut nor the Merrimack has yet been invaded by Zebra Mussels. The threat of

these mussels is very real, however, as they have taken hold and become a major scourge in nearby waters, e.g., the Hudson River and Lake Champlain.

Human Usage: Recreational use of these rivers, whether by boat or on foot, can degrade habitat and sometimes cause outright destruction of these species of concern. Boat wakes on the Connecticut River wash over large percentages of fragile emerging dragonflies and damselflies, causing death. Picnickers, hikers, and fishermen can trample the burrows of tiger beetles, causing the larvae to waste energy rebuilding their burrows more frequently than normal. Nesting Bald Eagles can be disturbed and caused to abandon their nests by close human approach, even if inadvertent.

Conservation Actions

Proposed actions aimed at conserving mainstem habitats in the future include:

- Determining site-specific Species Habitat Polygons for each current occurrence of a state-listed animal from the Connecticut or Merrimack mainstems, to inform land protection and regulatory priorities and actions;
- Surveying for rare riverine odonates to determine their range, abundance, and distribution in the state, as these species are undersurveyed in Massachusetts;
- Work through the FERC relicensing process to mitigate the effects of hydroelectric dams. Specifically, relicensed projects should have adequate upstream and downstream fish passage and should operate as run-of-river (no peaking);
- Work with the Massachusetts Department of Environmental Protection and the United States Environmental Protection Agency to implement sound wastewater management and eliminate the known urban CSO problems;
- Continue the ongoing interagency anadromous fish restoration programs on both the Connecticut and Merrimack Rivers;
- Pursue dam removal and fish passage projects to reconnect mainstem habitats to tributary habitats;
- Investigate the effects of mainstem dams on resident fish populations;
- Funding research on the natural history of river mainstem animals;
- Protecting land along these rivers through land purchases or conservation easements;
- Provide education to town conservation commissions to ensure proper enforcement and interpretation of the Wetlands Protection Act;
- Educating the public and private sectors about the importance of the Connecticut and Merrimack Rivers and how to protect them;
- Increasing regulation by proposing expansion of the Rivers Protection Act;
- Regulating and limiting the impacts of development on stretches of the Connecticut and Merrimack Rivers used by state-listed animals; and
- Using all conservation actions (including public education, agency publications, regulation, management, and protection) to conserve and restore mainstem river habitats.

Monitoring Conservation Action Effectiveness

The effectiveness of these proposed conservation actions will be monitored by assessing the:

- Number and percentage of the Species Habitat Polygon delineations used in regulatory reviews and land protection planning;

- Number of surveys completed for undersurveyed river mainstem animals;
- Number of stream surveys and inventories completed;
- Days spent monitoring anadromous fish populations at mainstem fish passage facilities, and changes in numbers of fish using the facilities;
- Number of Indexes of Biotic Integrity created, appropriate to stream fish communities in Massachusetts;
- Number of priority watersheds set for restoration, using target fish community methodologies;
- Number of priorities set within the watershed for restoration, using Meso-Habitat Simulation Model (MesoHabSim) to develop the priorities.
- Acres of land protected, through fee acquisition or conservation restriction, along stretches of these rivers supporting rare and uncommon animals;
- Number of research projects completed on river mainstem animal life histories;
- Number of proposed mainstem alterations reviewed and regulated by DFW each year;
- Number of conservation management permits (part of regulation of proposed developments) monitored, when those permits were issued by DFW for river mainstem species; and
- Number of conservation actions modified and adapted, using the results of monitoring.

2. Large and Mid-sized Rivers

Habitat Description

In Massachusetts, large and mid-sized rivers constitute most of the mainstem rivers and their larger tributaries. The Connecticut and Merrimack mainstems are described in a separate habitat category. There are 26 major basins in the state. These rivers, like the small streams that feed them, vary immensely, but some generalities do certainly apply. Gradient typically declines in these rivers from the higher gradient headwaters. Sediment sizes decrease and deposits of organically enriched soils deposit in greater amounts in widening floodplains. These rich floodplains are the foundation for productive floodplain forests, shrub swamps, and other habitats.

Large and mid-sized riverbeds shift and form braids and bend pools, as geology and gradient dictate. The rivers are typically not fully enclosed by tree canopies and begin to produce more of their energy through primary productivity. These changes in turn result in changes to the fauna that live within the habitat. The variability is probably best described by comparing the Taunton River to the Kinderhook River. The Taunton is a 48-mile river that drops only 20 feet along the mainstem, has large wetland areas, and is fed by more than 100 tributaries. The Kinderhook has only five river miles in Massachusetts, is high-gradient, and has only six small tributaries. Watersheds like the Housatonic have limestone contributions that buffer them from the impacts of acid rain, while the Millers and Westfield watersheds are very low in limestone and are more susceptible to the impacts of acid deposition. See Appendix H for maps of watersheds in Massachusetts.

Species of Greatest Conservation Need in Large & Mid-sized Rivers

State Listing Status	Taxon Grouping	Scientific Name	Common Name	State Status
State-listed	Fishes	<i>Acipenser brevirostrum</i>	Shortnose Sturgeon	E
		<i>Acipenser oxyrinchus</i>	Atlantic Sturgeon	E
		<i>Couesius plumbeus</i>	Lake Chub	E
		<i>Hybognathus regius</i>	Eastern Silvery Minnow	SC
		<i>Catostomus catostomus</i>	Longnose Sucker	SC
		<i>Lota lota</i>	Burbot	SC
	Reptiles	<i>Clemmys insculpta</i>	Wood Turtle	SC
	Birds	<i>Haliaeetus leucocephalus</i>	Bald Eagle	E
	Snails	<i>Ferrissia walkeri</i>	Walker's Limpet	SC
		<i>Pomatiopsis lapidaria</i>	Slender Walker	E
	Mussels	<i>Alasmidonta heterodon</i>	Dwarf Wedgemussel	E
		<i>Alasmidonta undulata</i>	Triangle Floater	SC
		<i>Alasmidonta varicosa</i>	Brook Floater	E
		<i>Lampsilis cariosa</i>	Yellow Lampmussel	E
		<i>Leptodea ochracea</i>	Tidewater Mucket	SC
		<i>Ligumia nasuta</i>	Eastern Pondmussel	SC
		<i>Strophitus undulatus</i>	Creeper	SC
	Odonates	<i>Boyeria grafiana</i>	Ocellated Darner	SC
		<i>Gomphus abbreviatus</i>	Spine-Crowned Clubtail	E
		<i>Gomphus desertus</i>	Harpoon Clubtail	E
		<i>Gomphus fraternus</i>	Midland Clubtail	E
		<i>Gomphus quadricolor</i>	Rapids Clubtail	T

State Listing Status	Taxon Grouping	Scientific Name	Common Name	State Status
		<i>Gomphus ventricosus</i>	Skillet Clubtail	SC
		<i>Neurocordulia obsoleta</i>	Umber Shadowdragon	SC
		<i>Neurocordulia yamaskanensis</i>	Stygian Shadowdragon	SC
		<i>Ophiogomphus aspersus</i>	Brook Snaketail	SC
		<i>Ophiogomphus carolus</i>	Riffle Snaketail	T
		<i>Stylurus amnicola</i>	Riverine Clubtail	E
		<i>Stylurus scudleri</i>	Zebra Clubtail	E
		<i>Stylurus spiniceps</i>	Arrow Clubtail	T
	Beetles	<i>Cicindela duodecimguttata</i>	Twelve-Spotted Tiger Beetle	SC
Not Listed	Fishes	<i>Alosa aestivalis</i>	Blueback Herring	--
		<i>Alosa pseudoharengus</i>	Alewife	--
		<i>Alosa sapidissima</i>	American Shad	--
		<i>Anguilla rostrata</i>	American Eel	--
		<i>Catostomus commersoni</i>	White Sucker	--
		<i>Enneacanthus obesus</i>	Banded Sunfish	--
		<i>Erimyzon oblongus</i>	Creek Chubsucker	--
		<i>Etheostoma fusiforme</i>	Swamp Darter	--
		<i>Etheostoma olmstedii</i>	Tessellated Darter	--
		<i>Luxilus cornutus</i>	Common Shiner	--
		<i>Petromyzon marinus</i>	Sea Lamprey	--
		<i>Rhinichthys atratulus</i>	Blacknose Dace	--
		<i>Rhinichthys cataractae</i>	Longnose Dace	--
		<i>Salmo salar</i>	Atlantic Salmon	--
		<i>Salvelinus fontinalis</i>	Brook Trout	--
		<i>Semotilus atromaculatus</i>	Creek Chub	--
		<i>Semotilus corporalis</i>	Fallfish	--
	Misc. Invertebrates	<i>Alloperla voinae</i>	A Stonefly	--
		<i>Hansonoperla appalachia</i>	Hanson's Appalachian Stonefly	--
		<i>Perlesta nitida</i>	A Stonefly	--

Most of the populations of Shortnose and Atlantic Sturgeon in Massachusetts are found in the Connecticut and Merrimack river mainstems, covered elsewhere. However, these fish do (and did, historically, to a greater extent) use a few other large rivers in the state. Although classified as an anadromous fish, the Shortnose Sturgeon is almost never found in the open ocean. Instead, individuals spend their lives in the rivers, undergoing migrations between discrete spawning, rearing, and feeding areas, including the estuary. Spawning occurs in the spring in rapidly moving sections of the mainstem rivers, now found only below dams. Atlantic Sturgeon are anadromous, entering large freshwater river systems to spawn during the spring. While there are no spawning populations of the Atlantic Sturgeon in Massachusetts, juvenile Atlantic Sturgeon can occasionally be found in the estuaries and lower portions of the major rivers during the summer months.

Lake Chubs and Longnose Suckers are found in cold, clear, fast-flowing rivers of the western third of the state. Lake Chubs are quite uncommon in the Westfield River, while Longnose Suckers are relatively more common, in the Westfield, Deerfield, Hoosic, and Housatonic drainages.

Slow-moving, low-gradient rivers, particularly those with shrubby or wooded areas adjacent, support Wood Turtles across much of Massachusetts. While most nesting pairs of Bald Eagles are on the mainstems of the Connecticut and Merrimack Rivers, nesting adults, as well as summering immatures and wintering or migrating eagles of all ages, use the state's large to mid-sized rivers for feeding.

Both Walker's Limpet and Slender Walker are each found in one small section of smaller rivers, both in the western part of the state. Seven rare freshwater mussels inhabit large to mid-sized rivers, most notably the federally Endangered Dwarf Wedgemussel, found only in tributaries to the Connecticut River. Thirteen species of rare dragonflies use a range of riverine habitats in Massachusetts, but many are found only in clear, swiftly flowing, relatively clean rivers over gravel, cobble or rocky substrates. The Twelve-spotted Tiger Beetle inhabits silt and clay deposits along rivers in western Massachusetts.

American Shad populations exist in many large to mid-sized coastal rivers, as well as in large to mid-sized tributaries of the Connecticut and Merrimack Rivers. American Shad are anadromous, migrating from the ocean to freshwater specifically to reproduce. Adult shad enter rivers in the spring, mid-April through June. Spawning occurs in the mainstem rivers and their larger tributaries in the early summer. Spawning usually occurs over gently sloping areas with fine gravel or sandy bottoms. After spawning, adult shad return to the sea. Fertilized eggs are carried by river currents and hatch within a few days. Larvae drift with the current until they mature into juveniles which remain in nursery areas (mainstem rivers and their larger tributaries), feeding on zooplankton and terrestrial insects. By late fall, most juvenile shad migrate to near-shore coastal wintering areas. Some juvenile shad will remain in mainstem rivers and estuaries up to a year before entering the ocean.

River herring (Alewife and Blueback Herring) populations exist in many large to mid-sized coastal rivers, as well as in large to mid-sized tributaries of the Connecticut and Merrimack Rivers. River herring spawn in mainstem rivers and tributaries from April to mid-July when water temperatures range from 51° (Alewife) or 57° (Blueback Herring) to 81° F. Upstream distribution of adults is a function of habitat suitability and hydrologic conditions permitting access to these sites. Immediately after spawning, surviving adult river herring migrate rapidly downstream to return to the sea. Alewives are still-water spawners and focus their reproductive efforts in the tidal portions of the rivers. In addition to the mainstem, alewives also use spawning habitat in backwaters and impoundments. Spawning can occur over a range of substrates such as gravel, sand, detritus, and submerged vegetation.

Blueback Herring spawning sites include swift-flowing sections of freshwater rivers, channel sections of fresh and brackish tidal rivers, and Atlantic coastal ponds over gravel and clean sand substrates. Blueback Herring often migrate farther upstream than do Alewives. Juvenile river herring occur in non-tidal and tidal freshwater and semi-brackish areas (mainstems and major tributaries) during spring and early summer, moving upstream during periods of decreased flows and encroachment of saline waters. Juveniles begin migrating from their nursery areas to the sea in the fall, cued by heavy rainfalls, high waters, or sharp declines in water temperatures.

The American Eel is a catadromous species, which spends most of its life in rivers, lakes and estuaries, but migrates to the ocean to spawn. Populations of American Eel occur in many large to mid-sized coastal rivers, as well as in large to mid-sized tributaries of the Connecticut and Merrimack Rivers. Some eels remain in the estuaries, but others migrate varying distances upstream, often for several hundred kilometers. American Eels will remain in the brackish and fresh waters of these rivers for the majority of their lives — for at least five and possibly as many as twenty years. Mature eels migrate back to the waters of the Sargasso Sea to spawn. The migration occurs throughout autumn nights, with adults descending streams and rivers to the estuaries for January spawning in the warm Caribbean waters.

Atlantic Salmon are anadromous, migrating from the ocean to freshwater specifically to reproduce. The Atlantic Salmon was extirpated from Massachusetts early in the 19th century, but restoration efforts are underway on both the Connecticut and Merrimack Rivers. All Atlantic salmon spawning and rearing habitat is found in the tributaries to the Connecticut and Merrimack river. Some of this habitat would be described as large to mid-sized rivers, and many large to mid-sized rivers serve as vital migration corridors to these habitats. Adults enter the rivers in the spring (April-June) and quickly migrate upstream and into tributaries. Adult salmon will spend the summer months in thermal refugia (deep pools) in these large to mid-sized rivers. After spawning in the fall, the surviving adults will either migrate downstream to the sea immediately or spend the winter in river before returning to the sea in the spring. Some large to mid-sized tributaries contain rearing habitat where several year-classes of juvenile salmon can be found year round. Two-year-old juvenile Atlantic salmon, known as smolts, undertake a migration to the sea in the spring. This migration from tributary to mainstem to estuary may take as long as three months for individuals migrating from far up in the watershed. This protracted migration period results in salmon smolts being present in larger tributaries throughout the spring (April-June).

Threats to Large and Mid-sized Rivers

Threats to large and mid-sized rivers come in two broad categories: 1) those inherited from small streams; and 2) those directly caused to the river or surrounding watershed area. Although the threats to small streams are described in that habitat summary, it bears mention that many threats facing large and mid-sized rivers can be alleviated through restoration in the small streams (Person, 1936). Threats to large and mid-sized rivers result in reductions to the physical habitat, water quality, and/or water quantity available for the species in greatest need of conservation. Watershed Assessment Reports, published by the Massachusetts Department of Protection, are available for these habitats at <http://www.mass.gov/dep/brp/wm/wqassess.htm>.

There is a great degree of variability in the threats facing the 26 major watersheds in Massachusetts. The riverine components (hydrology, geomorphology, biology, water chemistry and connectivity (Annear et al. 2004)) of all major basins in Massachusetts have been altered to some extent both temporally and spatially. The degradations of these components lead to alterations to the five elements of the natural flow regime (magnitude, frequency, duration, timing, and rate of change). Natural freshwater ecosystems are strongly influenced by specific facets of natural hydrological variability (Richter et al. 2003). Modification of flow thus has cascading effects on the ecological integrity of rivers (Poff et al. 1997). Some of the major perturbations, and the watersheds most impacted, are as follows:

Physical Habitat Alterations: Channelization, particularly near urban centers, has resulted in massive habitat loss in all watersheds, but especially in the Charles, Concord, Blackstone, North and South Coastal, and Merrimack watersheds. Portions of some rivers, e.g., the Hoosic River in Adams and North Adams, have actually been completely culverted and run through flood chutes instead of natural channels.

Dams on these rivers cause impacts to all watersheds in the state. The only mainstem considered to be free-flowing in the state is the Taunton River. In addition to currently inactive dams constructed during the last 300 years, there are also active dams that create impoundments for flood protection, industry (including cooling water and hydroelectric generation), and water supply. The Deerfield, Westfield, and Swift Rivers have the majority of hydroelectric generation (excluding on the Connecticut and Merrimack River mainstems, discussed elsewhere). Large-scale flood control projects exist on the Quinebaug, Westfield, and Millers Rivers. Water supply reservoirs are common statewide and range in size from the 25,000-acre Quabbin Reservoir to smaller secondary or backup water supply impoundments. These dams all result in a loss of physical habitat suitable for fluvial species within the impoundment, but other habitat impacts are also apparent. Stream flow downstream of almost all impoundments is severely restricted during low flow times of the year or when lakes are being refilled after an artificially induced lake drawdown. Minimum streamflow criteria are not regulated for most reservoir situations. Likewise, maximum streamflow is not regulated during artificial drawdowns when spring-like (or greater) flows are allowed to take place in times other than spring. These dams also cause a buildup of sediment, sometimes severely contaminated, within the impoundment and result in incised channels downstream of the impoundment. Incised channels further isolate the river channel from the surrounding floodplain.

Sewerage Treatment Effluent: Many of Massachusetts's large to mid-sized rivers are impacted by effluent from centralized sewerage treatment plants. In some cases, raw sewerage continues to be released into our waters. The Blackstone, Charles, Concord, and Nashua Rivers are particularly impacted. During summer low flows, the Blackstone and Assabet rivers (a tributary to the Concord River) are composed primarily of sewerage treatment effluent.

Stormwater runoff has caused substantial changes to water quality and causes erosion issues. Winter runoff often includes high concentrations of road salt, while stormwater flows in the summer cause thermal stress and bring high concentrations of other pollutants. Road, culvert, public water and sewer have created pathways, both intentional (CSO flows) and unintentional (inflow and infiltration) that have expedited the movement of rainfall and runoff into stream channels.

Water withdrawal and surface water diversion result in impacts to all of the basins to some extent, as illustrated in the Stressed Basins Report published by the Massachusetts Department of Conservation and Recreation, but especially to some of the higher quality rivers in the state. The Ipswich River continues to serve as the model for environmental degradation caused by water withdrawal. The Ipswich is impacted by both surface water diversion and groundwater withdrawal and was listed by American Rivers in 1997 as one of the 20 most threatened rivers in

the United States. Flows in the upper third of the watershed frequently become low or cease as a result of water withdrawals for public water supply (Armstrong et. al 2001).

Conservation Actions

Proposed actions aimed at conserving large to mid-sized river habitats in the future include:

- Determining Species Habitat Polygons for each current occurrence of a state-listed riverine animal;
- Surveying for riverine odonates and the Twelve-spotted Tiger Beetle to determine their range, abundance, and distribution in the state, as these species are undersurveyed in Massachusetts;
- Researching the natural history of riverine animals;
- Conducting research into determining the priorities for restoration of these habitats by examining, in each watershed, the relative impacts caused by the threats listed above (the Meso-Habitat Simulation Model (MesoHabSim));
- Provide methods for using biocriteria (Target Fish Communities) in water quality and quantity standards in Massachusetts;
- Identifying dam removal as a primary restoration tool and encouraging dam removal;
- Regulating and limiting the impacts of development on rivers used by state-listed animals;
- Providing education to town conservation commissions to ensure proper enforcement and interpretation of the Wetlands Protection Act;
- Increasing regulation by proposing expansion of the Rivers Protection Act;
- Protecting land along large and mid-sized rivers supporting populations of rare and uncommon animals;
- Educating and informing the public about the values of large and mid-sized rivers and the issues related to their conservation, through agency publications and other forms of public outreach, in order to instill public appreciation and understanding.

Monitoring Conservation Action Effectiveness

The effectiveness of these proposed conservation actions will be monitored by assessing the:

- Number and percentage of the Species Habitat Polygon delineations used in regulatory reviews and land protection planning;
- Number of surveys completed for undersurveyed riverine animals;
- Number of stream surveys and inventories completed;
- Number of research projects on riverine animal life histories completed;
- Use of target fish community methodologies to monitor the effectiveness of conservation actions;
- Number of priorities set within the watershed for restoration, using Meso-Habitat Simulation Model (MesoHabSim) to develop the priorities.
- Acres of land protected along large and mid-sized rivers supporting rare and uncommon animals;
- Number of proposed riverine alterations reviewed and regulated by DFW each year; and
- Number of conservation actions modified and adapted, using the results of monitoring.

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3. Marine and Estuarine Habitats

Habitat Description

Seaward of the sandy beaches and rocky coastlines, beyond the salt bays and estuaries, Massachusetts' territorial waters extend three nautical miles out into the Gulf of Maine (see Figure 23). The land under this area of open ocean is the relatively shallow continental shelf. Depths of seawater can range from a hundred feet or so to a little more than one thousand feet, but there are no deep trenches in Massachusetts waters. Almost all of Massachusetts salt waters are in estuaries and bays; very little — mostly just the waters east of the outer arm of Cape Cod — is open ocean.

A coastal bay is a large body of water partially enclosed by land but with a wide outlet to the ocean. Massachusetts has three great bays: **Massachusetts Bay** which includes the area between Gloucester on the south side of Cape Ann to Brant Rock, north of Plymouth, where the Commonwealth's second great bay, **Cape Cod Bay**, begins. It includes the area from Plymouth to the tip of Cape Cod. The third great bay is **Buzzards Bay** on the south side of Massachusetts, extending from the Westport River near the Rhode Island border, east to the Cape Cod Canal and south to the last of the Elizabeth Islands. Within the great bays are smaller bays such as Nahant Bay north of Boston and the Hull, Hingham, and Quincy bays south of Boston, all within the area designated Massachusetts Bay. Buzzards Bay likewise has smaller named bays within its confines.

There are separate small bays as well, though the designation between bays, coves, and harbors is sometimes blurred. Ipswich Bay and Essex Bay are located on the north side of Cape Ann; Duxbury, Kingston, and Plymouth bays at the juncture of Massachusetts and Cape Cod Bays; Pleasant Bay is found on the ocean side of outer Cape Cod; and a series of small bays are located on the south side of Cape Cod. Martha's Vineyard has its own small bays, though on Nantucket Island the Madaket area is referred to as a harbor.

Estuaries occur where fresh water rivers and streams reach the salt water areas of the coast. Estuaries are affected by tidal flows and are considered brackish water. The degree of salinity of estuaries varies along the length of the estuary and with tidal ebb and flow. Estuaries often have associated salt marsh habitat and are rich in nutrients, providing a valuable nursery for finfish, shellfish, and other macro- and micro-invertebrates, and support a wide range of vertebrate wildlife. Estuaries are vital links in the life history of diadromous fishes (species which spend a portion of their lives in freshwater and a portion in the sea). Diadromous fishes do not simply migrate through these areas; rather they rely on these complex ecosystems to provide food and protection while the physiological changes required to transition from life in fresh water to the sea (or vice versa) occur. The physical, chemical, and biological conditions present in the estuary are critical factors in this transition.

There are estuaries all along coastal Massachusetts, but the most extensive system lies just west of Plum Island, feeding into Plum Island sound and the marshes of Essex County, with a small subsystem along the Annisquam River on the north side of Cape Ann. A second extensive estuary system is found in the Nauset Marsh/Pleasant Bay area on outer Cape Cod. Numerous

shorter estuaries are found along the south side of Cape Cod. The East Branch of the Westport River is one of the longest estuaries in the Commonwealth.

A useful tool for conservation planning of marine and estuarine habitats is the Massachusetts Ocean Resources Information System (MORIS), developed by the Massachusetts Office of Geographic Information Systems and the Massachusetts Office of Coastal Zone Management. This includes georegulations datalayers depicting spatially what suite of statutes and regulations apply to different portions of state waters.

Species of Greatest Conservation Need in Marine & Estuarine Habitats

State Listing Status	Taxon Grouping	Scientific Name	Common Name	State Status
State-listed	Fishes	<i>Acipenser brevirostrum</i>	Shortnose Sturgeon	E
		<i>Acipenser oxyrinchus</i>	Atlantic Sturgeon	E
	Reptiles	<i>Caretta caretta</i>	Loggerhead Seaturtle	T
		<i>Chelonia mydas</i>	Green Seaturtle	T
		<i>Eretmochelys imbricata</i>	Hawksbill Seaturtle	E
		<i>Lepidochelys kempii</i>	Kemp's Ridley Seaturtle	E
		<i>Dermochelys coriacea</i>	Leatherback Seaturtle	E
		<i>Malaclemys terrapin</i>	Diamondback Terrapin	T
	Birds	<i>Oceanodroma leucorhoa</i>	Leach's Storm-Petrel	E
		<i>Haliaeetus leucocephalus</i>	Bald Eagle	E
		<i>Sterna dougallii</i>	Roseate Tern	E
		<i>Sterna hirundo</i>	Common Tern	SC
		<i>Sterna paradisaea</i>	Arctic Tern	SC
		<i>Sterna antillarum</i>	Least Tern	SC
	Mammals	<i>Physeter catodon</i>	Sperm Whale	E
		<i>Balaenoptera physalus</i>	Fin Whale	E
		<i>Balaenoptera borealis</i>	Sei Whale	E
		<i>Balaenoptera musculus</i>	Blue Whale	E
		<i>Megaptera novaeangliae</i>	Humpback Whale	E
		<i>Eubalaena glacialis</i>	Northern Right Whale	E
Not Listed	Fishes	<i>Alosa aestivalis</i>	Blueback Herring	--
		<i>Alosa pseudoharengus</i>	Alewife	--
		<i>Alosa sapidissima</i>	American Shad	--
		<i>Anguilla rostrata</i>	American Eel	--
		<i>Petromyzon marinus</i>	Sea Lamprey	--
		<i>Salmo salar</i>	Atlantic Salmon	--
	Birds	<i>Anas rubripes</i>	American Black Duck	--
		<i>Clangula hyemalis</i>	Long-tailed Duck	--
		<i>Egretta thula</i>	Snowy Egret	--
		<i>Histrionicus histrionicus</i>	Harlequin Duck	--
		<i>Somateria mollissima</i>	Common Eider	--
	Mammals	<i>Phocoena phocoena</i>	Harbor Porpoise	--

Although classified as an anadromous fish, the Shortnose Sturgeon is almost never found in the open ocean, rather individuals spend their lives in the mainstem river undergoing migrations between discrete spawning, rearing, and feeding areas- including the estuary. Atlantic Sturgeon are anadromous, entering large freshwater river systems to spawn during the spring. While there are no spawning populations of the Atlantic Sturgeon in Massachusetts, juvenile Atlantic

Sturgeon can occasionally be found in the estuaries and lower portions of the major rivers during the summer months. Both sturgeon species, as well as Blueback Herring, Alewives, American Shad, American Eel, and Atlantic Salmon, migrate through open ocean off Massachusetts, on their way to breed in freshwater or saltwater, depending on the species.

Sea turtles do not nest on Massachusetts beaches and islands, but the species above occasionally do regularly migrate or drift through Massachusetts waters in small numbers, feeding as they go. Diamondback Terrapin are not true sea turtles; they live in salt marsh and estuarine systems. Whales also move through Massachusetts waters, and regularly feed offshore, depending on prey availability. Harbor Porpoises stay in shallow waters off the coast, including shoal banks such as Jeffreys Ledge or, out of state waters, on Georges Bank.

The four species of rare terns that nest in Massachusetts are completely dependent on marine and, especially, estuarine habitats for all of their food. All four terns nest very close to salt water, on small islands, open beaches, or in the salt marsh. Common Eiders and Long-tailed Ducks gather in huge wintering flocks off the Massachusetts coast. Leach's Storm-petrels are most commonly seen as migrants off Massachusetts, although a few pairs nest on Massachusetts islands.

Adult American Shad enter coastal bays and estuaries in early spring (April) where they stage before beginning their migration to spawning grounds in freshwater rivers. Juvenile shad enter estuaries and coastal bays in the fall as zero-age migrants on their way to near-shore rearing habitat. Some juvenile shad will remain in the estuaries for up to one year before entering the ocean. Adult herring (Alewife and Blueback Herring) enter coastal bays and estuaries in early spring (April) where they stage before beginning their migration to spawning grounds in freshwater rivers. Juveniles begin migrating from their nursery areas to the sea in the fall, cued by heavy rainfalls, high waters, or sharp declines in water temperatures. Some juvenile herring will remain in the estuaries for up to one year before entering the ocean. Schools of juvenile herring are a significant forage base in our estuaries and coastal bays.

The American Eel is a catadromous species, which spends most of its life in rivers, lakes and estuaries, but migrates to the ocean to spawn. In autumn, juvenile eels (known as glass eels) migrate into estuaries along the Atlantic coast where they become pigmented. These eels are known as elvers. Some elvers remain in the estuaries, but others migrate varying distances upstream, often for several hundred kilometers. Now in their yellow eel phase, the American eels will remain in the brackish and fresh waters of these rivers for the majority of their lives — for at least five and possibly as many as twenty years. Females reach a maximum length of five feet, and males grow as long as two feet. Mature eels migrate back to the waters of the Sargasso Sea to spawn. The migration occurs throughout autumn nights with adults descending streams and rivers to the estuaries for January spawning in the warm Caribbean waters.

Mature adult Atlantic Salmon enter coastal bays and estuaries in early spring (April) where they stage before beginning their migration to spawning grounds in freshwater rivers. After spawning in the fall, the surviving adults will either immediately migrate downstream through the estuaries to the sea or they will spend the winter in the river before migrating through the estuaries to the sea in the spring. Two-year-old juvenile Atlantic Salmon, known as smolts, undertake a

migration to the sea in the spring. This migration from tributary to mainstem to estuary may take as long as three months for individuals migrating from far up in the watershed. This protracted migration period results in salmon smolts being present in estuaries throughout the spring (April-June).

Threats to Marine and Estuarine Habitats

Shoreline development has created the greatest threat to our coastal bays and estuaries. Massachusetts has lost close to 30 percent of its coastal wetlands due to development. While wetland protection laws passed in the 1970s have reduced large-scale wetland loss, incremental loss continues. The loss of coastal wetlands reduces the filtration ability provided by such wetlands to waters entering our bays and estuaries. Shoreline development results in more impervious surface with increased stormwater runoff and accompanying potential for sedimentation and toxic contamination. Recently, there has been a significant increase in proposals for energy and infrastructure projects along the coast, including wind farms, deep-water liquefied natural gas ports, desalination plants, and tidal energy projects.

Overflows and leaks from wastewater treatment plants and faulty septic systems can result in bacterial and pathogenic contamination and increase nitrogen loading in our coastal waters. This, in turn, promotes algae growth on eel grass bed to the detriment of this valuable aquatic food and cover source for fish, shellfish, marine invertebrates and waterfowl and other aquatic birds. Similarly, increased commercial and recreational boat traffic re-suspends sediments, further shading submerged vegetation. Direct discharge of waste from recreational boating and accidental oil spills from commercial shipping has been threats in the past and will continue in the future. A number of invasive species, such as Common Reed, Purple Loosestrife, Green Crabs, and Asian Shore Crabs, have taken hold in these habitats and threaten native species.

Marine and estuarine animals are also subject to injury or death from ship collisions, entanglement with nets, ingestion of anthropogenic objects (such as garbage, debris, and objects washed off ships), declines in prey species, pollution, disturbance of nesting or breeding areas, and, in some cases, harvesting of adults or eggs.

Conservation Actions

- Determining Species Habitat Polygons for each current occurrence of a state-listed marine and estuarine animal, where those occurrences intersect areas under Massachusetts jurisdiction;
- Salvaging specimens of and compiling data on stranded sea turtles, marine mammals and birds;
- Researching the natural history of marine and estuarine animals in Massachusetts waters;
- Mapping eelgrass beds through aerial surveys;
- Work with non-governmental organizations on volunteer wetland assessment programs;
- Pursue “No Discharge Area” plan for developing guidelines for personal watercraft use;
- Identify important eel grass beds and work to reduce turbidity caused by boat and recreational watercraft traffic;
- Identifying and understanding the impacts of invasive plants and animals;
- Limit human activities around nesting islands, sand bars, and beaches during the nesting season;

- Provide technical advice on stormwater issues to coastal municipalities;
- Provide non-point source pollution outreach to the public along coastal regions; and
- Support legislation to minimize chances of catastrophic oil spills.

Monitoring Conservation Actions Effectiveness

The effectiveness of these proposed conservation actions will be monitored by:

- Number and percentage of the Species Habitat Polygon delineations used in regulatory reviews;
- Numbers of stranded sea turtles, sea mammals, and birds salvaged, with compiled data sets;
- Number of research projects completed on marine and estuarine animal life histories;
- Percentage of eelgrass bed maps completed;
- Number of days per year shellfish beds must be closed to commercial and recreational clamming, due to pollution; and
- Number of conservation actions modified and adapted, using the results of monitoring.

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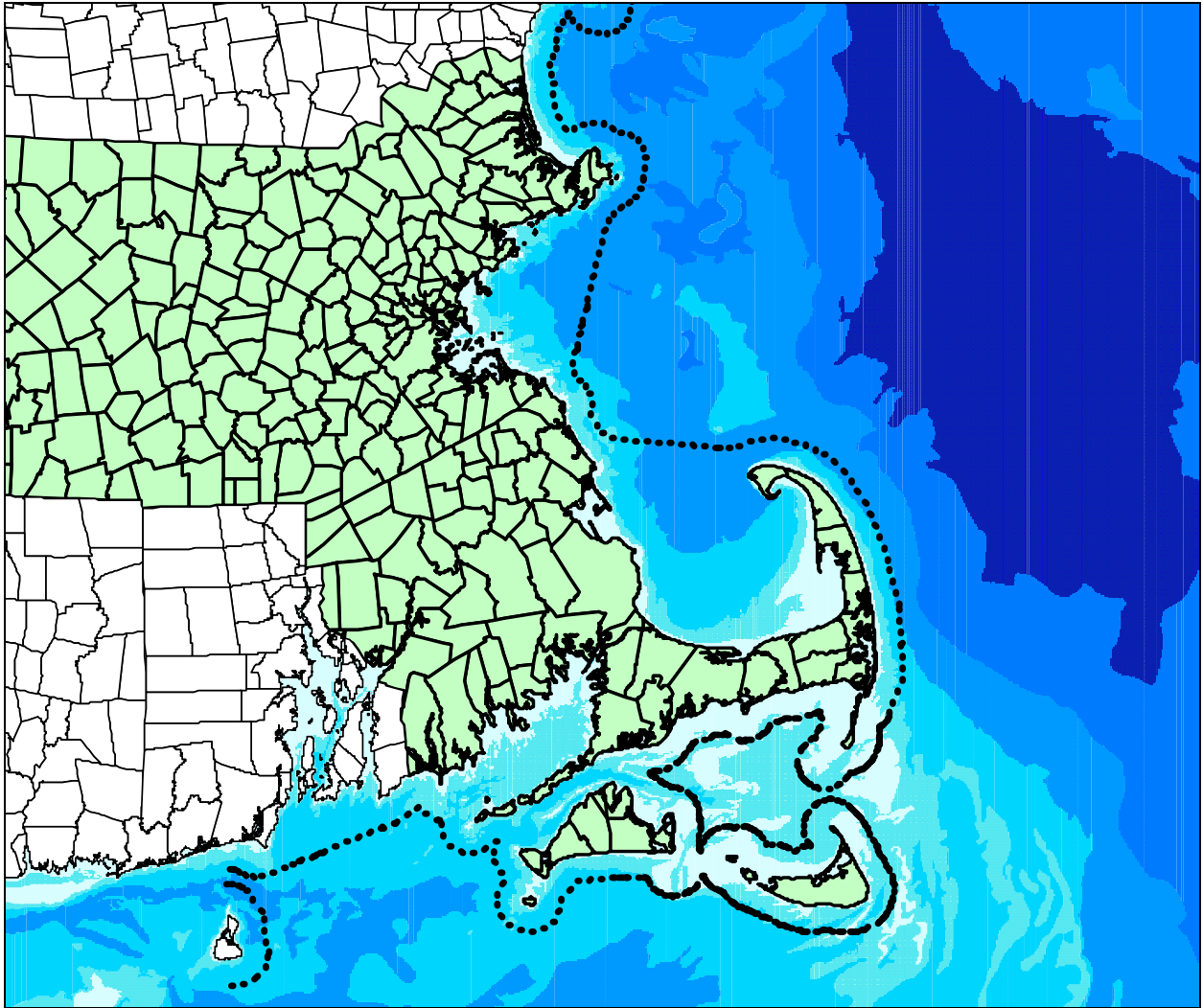


Figure 23: Marine & Estuarine Habitats under Massachusetts Jurisdiction.

4. Upland Forest

Habitat Description

Upland forest is land dominated by tree cover where soils are not saturated by water for extensive portions of the growing season. Today, and over the past several centuries, upland forest has provided the most extensive wildlife habitats in what is now the state of Massachusetts. About 62% (3 million acres) of the approximately 5 million acres in Massachusetts is forested today (Alerich 2000), and over 90% of today's forest is upland (94% upland forest vs. 6% wetland forest according to the MassGIS, DEP wetlands datalayer). Historically, forests covered the great majority of the state prior to European settlement, and it seems likely that more than 90+% of original forest cover occurred in uplands.

Two general types of upland forest occur in Massachusetts, namely northern hardwood (beech, birch, maple) forest (in western and north-central Massachusetts), and central hardwood (oak/hickory) forest (in eastern and south-central Massachusetts) (Figure 24). Within each of these two general types, two "sub-types" occur, including northern hardwood, hemlock, white pine and spruce-northern hardwood, along with oak-hickory/white pine/hemlock and pitch pine-oak. Within the northern hardwood region of Massachusetts (Figure 24), the northern hardwood/hemlock/white pine type is most common, with the spruce-northern hardwood type occurring only in the higher elevations of the northern Berkshire mountains of Western Massachusetts and the Worcester-Monadnock plateau of north-central Massachusetts. Within the central hardwood region of Massachusetts (Figure 24), oak-hickory/white pine/hemlock is most common, with pitch pine-oak occurring on the relatively infertile, sandy soils associated with coastal areas of eastern Massachusetts and portions of the Connecticut River valley in central Massachusetts.

Prior to European settlement, northern hardwood and central hardwood forest were separated by a relatively discrete tension zone that corresponded to physiographic, conditions, climate, and fire regime (Cogbill et al. 2002). This "tension zone" closely parallels the current U.S. Forest Service boundary between the New England – Adirondack and the Eastern Broadleaf Forest ecological provinces (Keys et al. 1995) (Figure 24). Today, mixtures of northern hardwood and central hardwood forest occur commonly in many portions of Massachusetts as a result of a dramatic alteration of the forest landscape throughout the 18th and 19th centuries associated with exploitive logging practices, and the conversion of forest to agriculture (Foster et al. 1998). U.S. Forest Service Forest Inventory Analysis (FIA) data recognizes five forest types in Massachusetts, with a current distribution of northern hardwoods (39%), oak-hickory (28%), white/red pine (17%), oak-pine (8%), and elm-ash-red maple (5%) (Alerich 2000).

Both northern hardwood and central hardwood forest types provide valuable structural attributes such as cavity and den sites (which are utilized by a variety of bird and mammal species), and coarse woody debris (which is utilized by various amphibian, reptile, and invertebrate species of wildlife). Perhaps the biggest difference in wildlife habitat between northern hardwood and central hardwood forest is that oak acorn production, an important source of wildlife food, is substantially greater in central hardwood forest than in northern hardwood forest. Oaks and acorns play a fundamental role in the organization and dynamics of eastern wildlife communities (Healy et al. 1997).

While some species of wildlife do not occupy upland forest, and instead require wetland or other aquatic habitats, upland forests provide important filters along wetlands, rivers and streams. These forests provide energy to the streams in the form of allocthonous material (e.g., leaves and associated nutrients from the organic material). Small streams rely on this energy almost exclusively to initiate their trophic interactions and food webs. Upland forests, through their root systems, also serve to stabilize soils and sediments in often high-gradient streams, thus minimizing erosion. Finally, upland forests help to moderate and regulate the temperature regime and fluctuations by providing shade to small streams. In addition, upland forests provides important habitat for wildlife species that occupy vernal pools throughout Massachusetts. With the exception of wildlife species that occupy coastal, grassland, or shrubland habitats, upland forests provide either direct or indirect habitat benefits to a substantial number of wildlife species of conservation concern in Massachusetts.

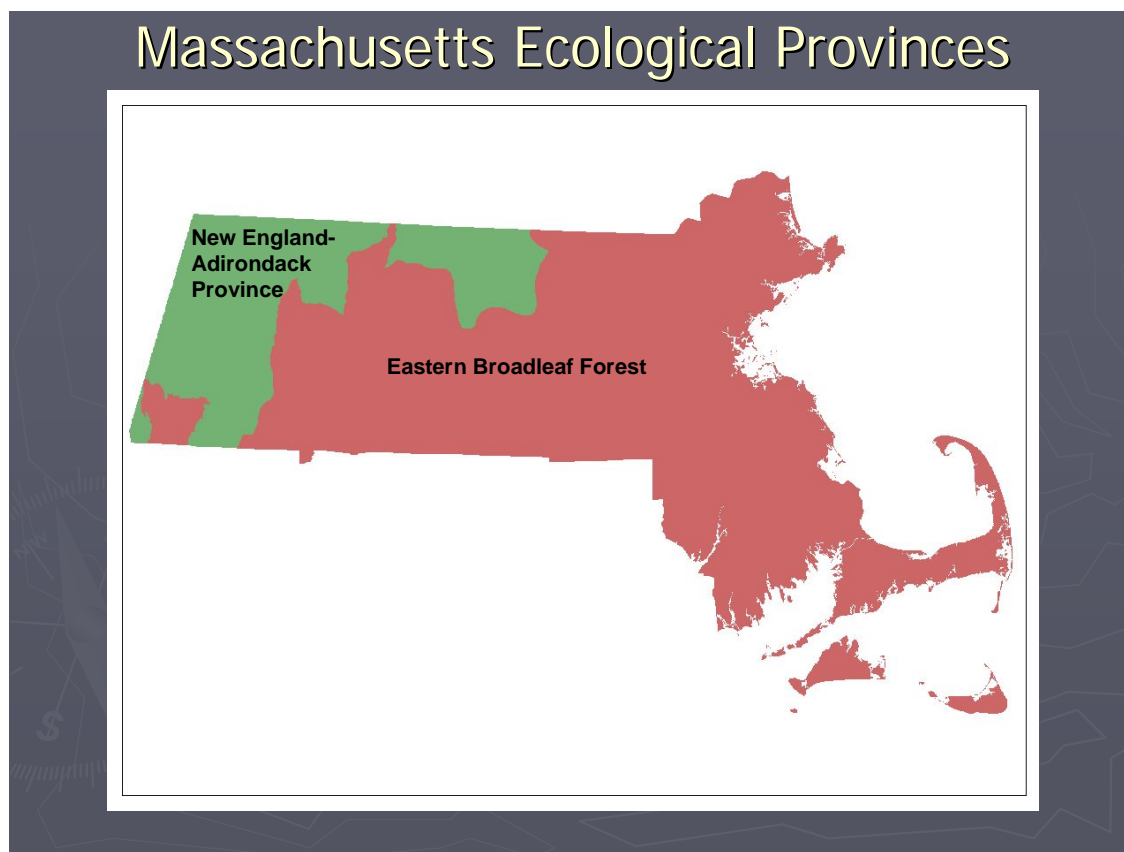


Figure 24: Massachusetts Ecological Provinces.

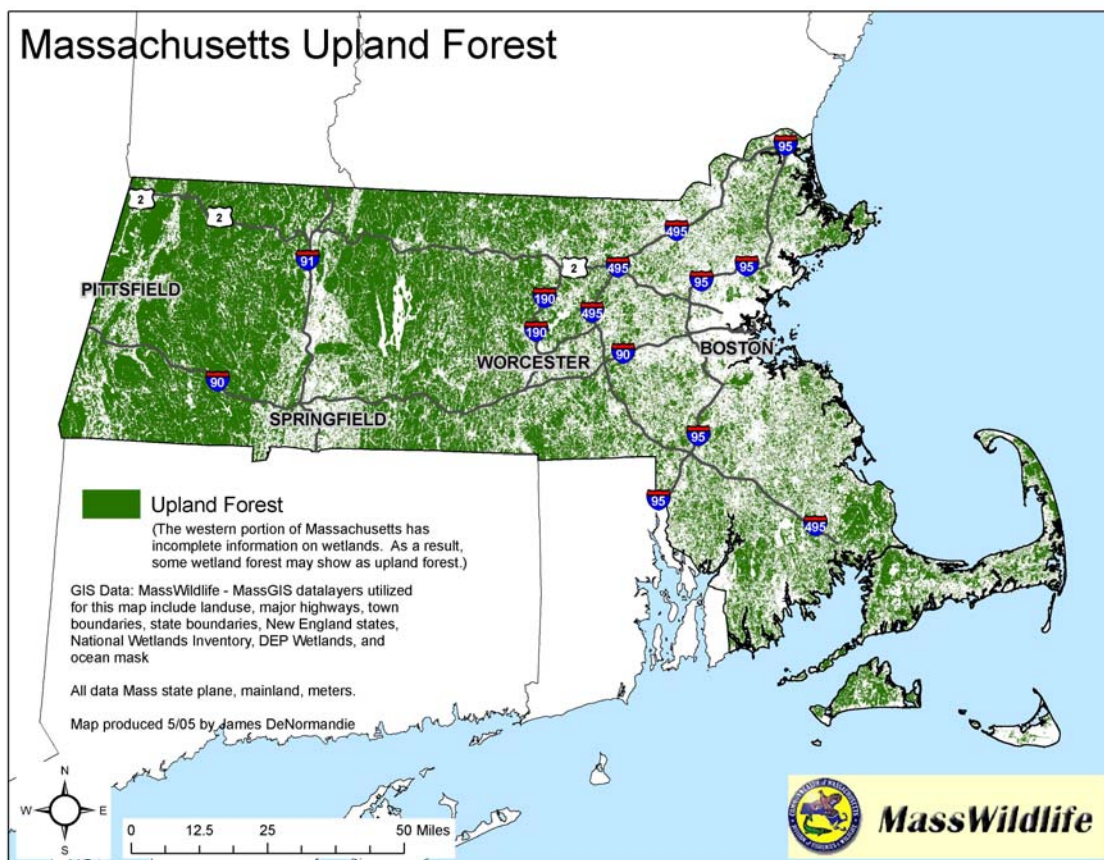


Figure 25: Upland Forest in Massachusetts.

Species of Greatest Conservation Need in Upland Forests

State Listing Status	Taxon Grouping	Scientific Name	Common Name	State Status
State-listed	Amphibians	<i>Ambystoma jeffersonianum</i>	Jefferson Salamander	SC
		<i>Ambystoma laterale</i>	Blue-Spotted Salamander	SC
		<i>Ambystoma opacum</i>	Marbled Salamander	T
		<i>Hemidactylium scutatum</i>	Four-Toed Salamander	SC
		<i>Scaphiopus holbrookii</i>	Eastern Spadefoot	T
	Reptiles	<i>Terrapene carolina</i>	Eastern Box Turtle	SC
		<i>Carphophis amoenus</i>	Eastern Wormsnake	T
		<i>Elaphe obsoleta</i>	Eastern Ratsnake	E
		<i>Agkistrodon contortrix</i>	Copperhead	E
		<i>Crotalus horridus</i>	Timber Rattlesnake	E
	Birds	<i>Accipiter striatus</i>	Sharp-Shinned Hawk	SC
		<i>Asio otus</i>	Long-eared Owl	SC
		<i>Parula americana</i>	Northern Parula	T
		<i>Dendroica striata</i>	Blackpoll Warbler	SC
	Lepidoptera	<i>Erora laeta</i>	Early Hairstreak	T
		<i>Rhodoecia aurantiago</i>	Orange Sallow Moth	T
		<i>Satyrium favonius</i>	Oak Hairstreak	SC
Not Listed	Reptiles	<i>Coluber constrictor</i>	Black Racer	--

State Listing Status	Taxon Grouping	Scientific Name	Common Name	State Status
	Birds	<i>Buteo platypterus</i>	Broad-Winged Hawk	--
		<i>Hylocichla mustelina</i>	Wood Thrush	--
	Mammals	<i>Lasionycteris noctivagans</i>	Silver-haired Bat	--
		<i>Lasiurus borealis</i>	Eastern Red Bat	--
		<i>Lasiurus cinereus</i>	Hoary Bat	--
	Lepidoptera	<i>Pieris virginiensis</i>	West Virginia White	--

Jefferson Salamanders, Blue-Spotted Salamanders, Marbled Salamanders, Eastern Spadefoots, and, to a lesser extent, Four-Toed Salamanders are all highly dependent on vernal pools as breeding sites. However, except for the short period annually when these species are breeding, they inhabit upland forests in the vicinity of vernal pools, up to a distance of 600 meters or more from the pools. Upland forests also serve as connecting corridors among vernal pools, allowing dispersal and re-colonization of these impermanent resources by these amphibians.

Rare reptiles — Eastern Box Turtle, Eastern Wormsnake, Eastern Ratsnake, Copperhead, Timber Rattlesnake — also depend on upland forests for shelter and food. Sharp-shinned Hawks, Broad-winged Hawks, and Long-eared Owls find protection for their nests in these forests, as well as their prey species. Northern Parula warblers nest in upland forests in southeastern Massachusetts, while Blackpoll Warblers choose only the stunted spruce forests of the far northwest of the state. Wood Thrushes nest almost throughout the state, but are sensitive to the degree of fragmentation of their preferred upland forest habitat.

Three uncommon bats — Silver-haired, Eastern Red, and Hoary Bats — use upland forests for nesting and migration in Massachusetts, but very little is known about the extent of this use. Silver-haired Bats are not known to nest in Massachusetts, and the only nesting records for Eastern Red Bats are historical.

As widespread as upland forests are in Massachusetts, they support three state-listed and one uncommon lepidoptera. Both West Virginia White and Early Hairstreak butterflies inhabit upland forests in western Massachusetts, but the White prefers rich, mesic woods and the Hairstreaks prefer beech forests. In eastern Massachusetts, the Oak Hairstreak chooses dry, open oak woodlands. Orange Sallow Moth caterpillars eat the developing seeds of false foxglove plants, which are themselves semi-parasitic on oaks, prefer open shade, and seem to germinate best in the bare soil left by occasional fires. Many more rare moths inhabit the pitch pine/scrub oak forests of southeastern Massachusetts and are described in the summary for that habitat.

Threats to Upland Forest

Development, invasive species, and forest cutting practices are the most serious threats to upland forest habitat in Massachusetts. Despite the fact that Massachusetts was the only state in the nation in which the U.S. Census reported a decline in its human population in 2004, development continues to convert forest to residential and suburban developments. More than 157,000 acres were developed in Massachusetts between 1985 and 1999 (an annual average of about 11,200 acres/year), and virtually all of this land had been forested habitat (Breunig 2003).

Approximately 132 million board feet of timber are harvested annually in Massachusetts (Alerich 2000). Only 45% (about 60 million board feet) can be accounted for from harvesting on

land that remains in forest use (Dept. of Conservation and Recreation 2005). The remaining 55% (about 72 million board feet) is apparently cut from land as it is converted to non-forest use. This estimate can be verified using forest inventory analysis (FIA) data from the U.S. Forest Service, and land use data from the Massachusetts Audubon Society. With an average of about 6,300 board feet per acre of Massachusetts forestland (Alerich 2000), and an average of 11,200 acres of forestland developed annually throughout the state, approximately 71 million board feet of timber is generated annually from forested land converted to development.

Forest cutting practices in Massachusetts typically involve partial overstory removal that is generally not favorable to regeneration of oak genera. Forest harvest operations in Massachusetts commonly remove about one-third (2.1-2.2 mbf per acre (DCR 2005)) of the approximately 6.2 total mbf per acre (Alerich 2000), and thus do not open the forest canopy adequately to secure oak regeneration. In much of the northeastern U.S., oak is not regenerating successfully on mesic sites amenable to growing oak, and is gradually being replaced by more shade-tolerant tree species such as red maple and black birch (Lorimer 1993, Healy et al. 1997). This trend is evident in Massachusetts, where the total area dominated by oak forest declined from about 35% to about 28% between 1985 and 1998 (Alerich 2000).

Forest cutting associated with conversion of forest to development often results in loss of shade and stability to small and large streams and rivers, thereby increasing siltation, erosion, and temperature regimes. This contributes directly to the decline in the habitats and species in greatest need of conservation of these watercourses.

Invasive species lead to alteration of forest ecosystems in Massachusetts, and threaten to cause increasingly more dramatic alterations in the coming decades. Introduced fungi are responsible for chestnut blight, Dutch elm disease, beech bark disease, and butternut canker, while introduced insects have brought gypsy moth and hemlock wooly adelgid to Massachusetts forestlands (Gottschalk and Liebhold 2004). An emerging invasive fungal threat involves *Ranorum* blight (a.k.a. sudden oak death), which was first documented in California, and has the potential to devastate eastern oak forests if it becomes established here (Gottschalk and Liebhold 2004). Other invasive, exotic insects that could become established in Massachusetts forests include the Asian long-horned beetle (which often attacks maple trees) and emerald ash borer beetle.

Conservation Actions

The Division of Fisheries & Wildlife (DFW) is involved in private/public partnerships to secure funding for protection of open space. The Natural Heritage section of DFW has produced two publications (BioMap and Living Waters) to help guide proactive land protection efforts to conserve rare plants and animals. DFW has also created a GIS datalayer to identify forest interior habitat that is buffered from fragmentation associated with roads and development. The forest interior datalayer can help guide proactive land protection efforts to conserve extensive, relatively un-fragmented forestlands that benefit a range of wildlife species. Viable populations of wide-ranging species such as black bear and moose may best be conserved within extensive, heavily forested landscapes. In addition, smaller wildlife species including some forest songbirds have higher likelihood of nesting successfully in larger rather than smaller forest patches (Robbins 1989). In extensive (unfragmented) forest environments, isolation (distance from the

nearest forest edge) is the best predictor of density and richness for interior forest birds (Askins et al. 1987, Askins et al. 1991). Ideally, sites that comprise BioMap, Living Waters, and Forest Interior habitats should constitute the highest priority of conservation of open space.

DFW employs both “fee simple” acquisitions (where land is transferred from private to public ownership), and “conservation easements” (where land remains in private ownership, but development and public access rights are transferred to the state). Fee simple acquisitions are generally preferred for conservation of rare species habitat and priority natural communities. Conservation easements offer a cost-effective way to protect extensive forestlands that buffer rare habitats and communities since easements typically cost 20-40% less than fee simple acquisitions.

Also, DFW will participate in a task force organized through the Massachusetts Department of Conservation and Recreation (DCR) to identify invasions of exotic fungal and insect pests that threaten the state’s forests. The task force will work cooperatively with both public and private conservation organizations to contain or eradicate identified invasions that threaten commercial forest resources.

Lastly, DFW will continue to employ even-aged forest cutting practices that can successfully regenerate oak genera. These efforts can serve as a model for private forest landowners who have a goal of providing good fish and wildlife habitat on their lands.

Additional actions aimed at conserving upland forest animals also include, assuming adequate funding:

- Determining site-specific Species Habitat Polygons for each current occurrence of a state-listed upland forest animal, to inform land protection and regulatory priorities and actions;
- Surveying for nesting Long-eared Owls, Silver-haired, Eastern Red, and Hoary Bats to determine their range, abundance, and distribution in the state, as these species are undersurveyed in Massachusetts;
- Regulating and limiting the impacts of development on upland forest used by state-listed animals; and
- Funding research on the natural history of rare and uncommon upland forest animals.
- Educating/informing the public about the values of upland forest habitats and the issues related to their conservation, through agency publications and other forms of public outreach, in order to instill public appreciation and understanding.

Monitoring Conservation Action Effectiveness

DFW can track the acreage of fee simple acquisitions and conservation easements within and outside of BioMap, Living Waters, and Forest Interior habitats as the primary means to monitor the impact of conservation actions. Ideally, a majority of acquisitions will occur in these high priority sites, and many acquisitions will occur where all three types of habitat overlap.

Likewise, DFW can review progress reports generated by the DCR task force to identify and control invasive organisms that threaten commercial forest resources. Finally, DFW can track the

acreage of applications of even-aged silviculture on both state and private lands by reviewing the DCR Chapter 132 database.

Further monitoring of the proposed conservation actions will include assessing the:

- Number and percentage of the Species Habitat Polygon delineations used in regulatory reviews and land protection planning;
- Number of research projects completed on upland forest animal life histories;
- Number of survey projects completed for undersurveyed upland forest animals;
- Number of proposed upland forest alterations reviewed and regulated by DFW each year;
- Number of conservation management permits (part of regulation of proposed developments) monitored each year, which were issued by DFW for upland forest species; and
- Number of conservation actions modified and adapted, using the results of monitoring.

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5. Large Unfragmented Landscape Mosaics

Habitat Description

“Large landscape mosaics” refers to the aggregation of habitat patches, corridors, and matrices of adequate size and connectivity to support residency and long-term viability of wildlife populations, particularly those of wide-ranging mammals such as bobcat (*Lynx rufus*), black bear (*Ursus americanus*), and moose (*Alces alces*) which may serve as focal species for landscape level habitat assessments. Similarly, but on a smaller overall scale, Blanding’s (*Emydoidea blandingii*) and Spotted Turtles (*Clemmys guttata*) move considerable distances (up to 2 km for Blanding’s) among feeding, nesting, estivating, and over-wintering habitats, incurring increased vehicular mortality as a result. The relatively large home ranges and varied habitat requirements of these animals extend beyond habitat patches to landscape mosaics that are comprised of a mix of ecosystems on a scale of kilometers.

A more precise definition and measurement of the suitability of large landscape mosaics likely depends on the species; however, natural lands which include both forest and open wetlands may be considered as a general descriptor for this habitat type. Based on a landscape analysis, natural lands are primarily (90%) composed of forest, but also include open wetland habitats, and comprise about 63.5% of Massachusetts. Large natural areas occur mainly west of the Connecticut River, with one large area that spans several ecoregions (564,955 ha).

The concept of this habitat type may also be approached by identifying the aggregation of interior forest areas (forest buffered by varying distances from fragmenting landuse features such as roads and development). An analysis of interior forest and interior natural lands in Massachusetts shows that only 11.6% of Massachusetts is interior forest and those interior natural lands comprise 12.5% of the state.

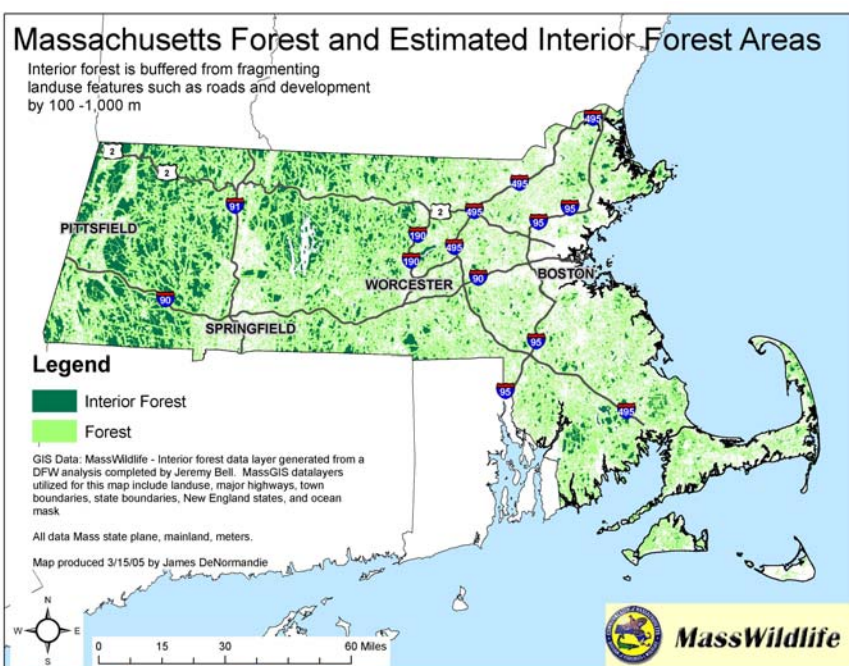


Figure 26: Interior Forest in Massachusetts.

Species of Greatest Conservation Need in Large Unfragmented Landscape Mosaics

State Listing Status	Taxon Grouping	Scientific Name	Common Name	State Status
State-listed	Reptiles	<i>Clemmys guttata</i>	Spotted Turtle	SC
		<i>Emydoidea blandingii</i>	Blanding's Turtle	T
Not Listed	Mammals	<i>Alces alces</i>	Moose	--
		<i>Lynx rufus</i>	Bobcat	--
		<i>Ursus americanus</i>	Black Bear	--

Turtles

Spotted and Blanding's Turtles are long-lived reptiles, with delayed reproductive maturity (about 8 years for Spotted, 17.5 years for Blanding's), low annual reproductive output (2-7 eggs/year for Spotted, 3-22 eggs/year for Blanding's), and high mortality rates in the egg and hatchling stages. These life-history characteristics imply that adult turtles must have a very high annual survivorship rate (estimated at 93% or greater) to offset low recruitment to adult ages and, thus, maintain stable populations (Congdon et al. 1993, Fowle 2001).

Additionally, a population of Blanding's or Spotted Turtles uses a variety of wetland and upland habitats in a single year. Individual turtles can also move long distances between habitat types in a single year.

Blanding's Turtles in New England use ponds, rivers, marshes, fens, vernal pools, shrub swamps, forested swamps, streams, meadows, forests, and shrublands for foraging, estivating, overwintering, basking, hydrating, and movement between wetlands. Nesting sites include meadows, fields, pastures, bedrock outcrops, sand and gravel pits, dirt roads, and roadsides (Fowle 2001, Joyal et al. 2001). Joyal et al. (2001) found Blanding's Turtles in southwestern Maine to spend greater than 50% of their time from May to September in permanent pools, and 38% of their time in uplands of various types. In Massachusetts, Milam and Melvin (2001) documented that Spotted Turtles spent about two-thirds of their active season in seasonal pools. Fowle (2001), summarizing several studies of radio-tracked Blanding's Turtles, noted the maximum average of 680 meters in one study, with a maximum of 2900 meters in another, traveled between wetlands. The maximal average distance traveled to nesting sites was 895 meters, with a maximum single distance of 1620 meters.

Spotted Turtles in New England use ponds, emergent marshes, shrub swamps, forested wetlands, fens, wet meadows, seasonal pools, streams, rivers, forests, and other upland habitats. Nesting sites include open, non-forested uplands such as meadows, fields, pastures, sand and gravel pits, and roadsides, as well as hummocks in emergent wetlands and red maple swamps (Fowle 2001, Joyal et al. 2001). In the same landscape as the Blanding's Turtles reported above, Joyal et al. (2001) found Spotted Turtles to spend about a third of their time in permanent pools. In 1992 Spotted Turtles spent more time in seasonal pools than in other habitats (permanent pools, uplands, forested swamps, and wet meadows), but in 1993, a drier year, they spent the largest percentage of their time in uplands. Overall, Spotted Turtles in this study spent about 74% of May through September in uplands. Fowle (2001) summarized movements of radio-tracked Spotted Turtles to nest sites and reported an average of 249 meters and a maximum of 570 meters. Maximum distance traveled between wetlands was 1150 meters.

Thus, these turtles use surprisingly large areas of landscape mosaics to carry out yearly activities. Coupled with the requirement for very high adult survivorship and the susceptibility to vehicular mortality while moving, protecting populations of Blanding's and Spotted Turtles will require large landscapes composed of various wetlands and uplands in close proximity, unfragmented by roads and other development. Since, in Massachusetts, Blanding's and Spotted Turtles occur primarily east of the Connecticut River, the more heavily developed and fragmented part of the state, conserving these species over the long-term will prove particularly difficult.

Mammals

Depending on sex, seasonality, and region, home ranges for bobcat, black bear and moose will vary substantially. Home ranges for adult bobcats may vary from 2 to 123 km² for males and 1 to 70 km² for females (Anderson and Lovallo 2003). Adult female (>2 yrs) black bear home ranges in two western Massachusetts study areas averaged 23 and 26 km² (Fuller 1993) and adult males (Elowe 1984) 328 km². Studies in northern New England have shown mean summer home-range sizes for moose of 2 to 60 km² to as much as 93 km² and 153 km² (DeGraaf and Yamasaki 2001).

While the home ranges and particular habitat features required by these focal species have been studied (DeGraaf and Yamasaki 2001), their sensitivity to fragmentation of the landscape and landscape mosaic area size is not well known in Massachusetts. There is increasing evidence that variables such as habitat patch size, distribution, and connectivity significantly affect biodiversity and wildlife populations at the landscape scale (Manville 1983, Mattson 1990, Forman 1995). In eastern Massachusetts, road effects extended outward >1 km for moose corridors (Forman and Deblinger 2000). Hammond (2002) found that in Vermont adult male bears avoided areas within 200m of permanent houses and adult females within 200 to 400m, depending on season. Adult males avoided paved roads out to 400m and adult females out to 300m (Hammond 2002). Lovallo and Anderson (1996) found that in Wisconsin areas ≤100 m from roads contained less preferred bobcat habitat than roadless areas. Geographic and behavioral selection appeared to be a function of vehicular traffic levels and the proximity of preferred habitat to road types.

Threats to Large Unfragmented Landscape Mosaics

Fragmentation and habitat loss are frequently identified as primary threats throughout this document and directly relate to the definition of large unfragmented landscape mosaics. The two major causes for habitat loss and fragmentation are human development and road networks, which break up habitats into smaller pieces and isolate those habitats by creating barriers and resistance to animal movement.

Fowle (2001), in her summary of threats to Blanding's and Spotted Turtles (among other reptiles and amphibians), notes that roads, railroad tracks, fences, retaining walls, and curbs can all serve as barriers to turtle movements, thus isolating populations and increasing their chances of local extinction. Direct wetland loss is also identified as a threat, as well as activities that degrade the habitat value of the wetlands or their immediate vicinity, such as loss or thinning of forest canopy or removal of rocks or coarse woody debris (which shelter prey such as amphibians). Turtles can also be threatened by the edge effects of human residential use, such as an increase in

mesopredators (raccoons, skunks), the taking of turtles as pets, injuries or mortality caused by pets, and disturbance of nesting activity by humans or their pets.

The sensitivity of wildlife to decreasing patch size has been shown in California for mammalian carnivores such as mountain lions (*Puma concolor*), bobcats, and coyotes (*Canis latrans*), where the probability of occurrence of individuals of those species decreases as habitat patches became smaller and more isolated. However, sensitivity to these landscape variables depends on the species (Crooks 2002). Bobcats were found to have significantly greater sensitivity to size and isolation than coyotes and mesopredators such as raccoons (*Procyon lotor*), skunks (*Mephitis* sp. and *Spilogale* sp.), and opossums (*Didelphis virginiana*). For black bears, Rogers and Allen (1987) estimated that at a density of 1 bear/4.5 km², a population of 34 bears required a living area of 154 km², or 3.9 km² per human habitation (1.1 km radius). Bobcats generally prefer rough rocky terrain interspersed with dense cover (Anderson and Lovallo 2003), which provides an abundance of prey. Habitat characteristics influence the diversity and abundance of prey populations, and so partially regulate bobcat density and home range.

Wide-ranging species such as bobcat, black bear, and moose may also be especially sensitive to road density (Paquet and Hackman 1995, Hammond 2002, Lovallo and Anderson 1996). The following characteristics have been identified that increase a species vulnerability to road effects such as road mortality, habitat loss, and reduced connectivity between habitats (Forman and Sperling 2003):

- Attraction to road habitat
- High intrinsic mobility
- Habitat generalist
- Multiple-resource needs
- Low density / large area requirement
- Low reproductive rate
- Forest interior species
- Behavioral avoidance of roads

Direct habitat loss through human development is an obvious threat, but the consequence of human development poses a more indirect subtle threat by artificially increasing, modifying or degrading the food biomass available to species. In part, increased availability of food combined with road / infrastructure networks attract wide-ranging mammalian species into human-dominated landscapes. While these species may occur in suburban or urban landscapes, such landscapes may not necessarily ensure the long-term residency or persistence of these species. At present, populations of black bear and moose are increasing in Massachusetts, despite the fact that some 10,000 acres of forest are annually converted to suburban development. While these population increases within a landscape that is continually being developed may be seen as a benefit to the species population, they may also be the result of semi-urbanized landscape conditions that are still within the tolerance of these species. Further, the tolerance of humans to the presence of these species within more urbanized communities may pose special conservation challenges in the future. Clearly, at some point along the continuum of fragmentation and development, the availability of landscape mosaics to support the residency of certain species will diminish.

Conservation Actions

Research and monitoring

- Determining site-specific Species Habitat Polygons for each current occurrence of a state-listed landscape mosaic animal, to inform land protection and regulatory priorities and actions;
- Researching large landscape mosaics and their ability to support residency of species with large home ranges and sexually selected dispersal patterns, as well as supporting other wildlife populations within Massachusetts;
- Examining the sensitivity of focal species populations to fragmentation from roads, development, and changing landuse patterns;
- Determining the minimum land area and habitat features needed to protect meta-populations of landscape mosaic species, for use in conservation planning;
- Prioritizing large unfragmented landscape mosaics across the state as targets for survey and conservation efforts;
- Synthesis of research and survey findings, with subsequent production of conservation guidelines;

Land protection

- Identifying and prioritizing large landscape mosaics that are critical to the conservation of focal species and biodiversity within the state;
- Cultivate government and private partnerships focused on large-scale natural area protection, particularly in areas west of the Connecticut River, for mammals; in northeastern Massachusetts, for Blanding's Turtles; and east of the Quabbin Reservoir, for Spotted Turtles;
- Develop mitigation guidelines for road construction to minimize isolation and mortality effects on wildlife;
- Develop guidelines for community developments that minimize fragmentation of large landscape mosaics;

Regulation

- Regulating and limiting the impacts of development on large unfragmented landscape mosaics used by state-listed animals;
- Monitoring construction or alteration projects regulated by DFW, for the impacts on landscape mosaic species;

Public education

- Educate the public about the value of large landscape mosaics or natural areas in supporting focal species populations and biodiversity within Massachusetts.

Monitoring Conservation Action Effectiveness

The effectiveness of these proposed conservation actions will be monitored by assessing the:

- Number and percentage of the Species Habitat Polygon delineations used in regulatory reviews and land protection planning;
- Number of research projects completed on landscape mosaic animal life histories;

- Percentage of the state examined for large unfragmented landscape mosaics, suitable for supporting populations of landscape mosaic animals;
- Number of acres of large unfragmented landscape mosaics protected, through fee acquisition or conservation restriction, supporting rare and uncommon animals;
- Percentage of mitigation guidelines for road construction completed;
- Number of proposed landscape mosaic alterations reviewed and regulated by DFW each year;
- Number of conservation management permits (part of regulation of proposed developments) monitored, when those permits were issued by DFW for landscape mosaic species; and
- Number of conservation actions modified and adapted, using the results of monitoring.

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6. Pitch Pine/Scrub Oak

Habitat Description

Pitch Pine/Scrub Oak (PPSO) applies to a broad suite of closely related, highly dynamic vegetation communities best described as a continuum. There are an infinite number of combinations of scrub oaks, tree oaks, pitch pine, heaths, grasses and forbs all sharing some common denominators.

Pitch Pine/Scrub Oak comprises more than 100,000 acres of Massachusetts and serves as primary habitat for an extraordinary portion of protected Massachusetts animal populations. Only a small fraction of this acreage is receiving appropriate management and restoration actions, without which this suite of natural communities will inevitably disappear from the Commonwealth.

Pitch Pine/Scrub Oak communities occur on coarse sandy substrates that drain rapidly or on ridgetops with exposed bedrock. PPSO communities are associated primarily with the glacial moraines and outwash plains of southeastern Massachusetts, but inland occurrences were not infrequent historically, especially those that developed on the large sandplains formed when periglacial rivers poured coarse sediments into glacial lakes, forming thick deltaic deposits. PPSO communities are all disturbance-dependent and influenced by periodic fire, ice storms, tropical storms, insect irruptions, salt spray, land use history, and combinations of these and other factors.

Pitch Pine/Scrub Oak composition and architecture depends on the timing, frequency, severity, intensity, and types of disturbances to which it is exposed. Frequent disturbance produces a community dominated by low multi-stemmed scrub oak, with sparse emergent pitch pines, tree oaks with interspersed heath and grass patches, or a scrub oak savanna, for example. Due to the constant exposure to wind and annual ice storm events, a similar structure and composition is found on ridgetops in the western ecoregions of the state. Reduction in disturbance frequency and intensity results in a more closed-canopy structure, where tree oaks and pitch pine are dominant, though scrub oak, huckleberry and blueberry species, and occasional grass patches remain. Another phase in the continuum is composed of tree oaks over a shrub layer dominated by black huckleberry. Land use history, particularly logging, charcoaling, and agriculture, has had profound influences on PPSO systems. Recent studies have revealed that intense agricultural plowing often resulted in a community typified by a reduced diversity of ericads, under a dense canopy of pitch pine, with sparse scrub and tree oaks. Unplowed areas of PPSO support resprouting tree and scrub oak individuals, whose belowground components are hundreds of years old.

The most important feature of the PPSO continuum is that all the patches are important to maintaining a diversity of rare invertebrate populations and assemblages. Perhaps the simplest expression to convey the dynamism of Pitch Pine/Scrub Oak communities is:

Disturbance diversity = Habitat heterogeneity = Diversity of plant and animal species.

Some phases of the Pitch Pine/Scrub Oak continuum include patches of sparsely vegetated mineral soils resulting from severe wildfires that consumed all available organic matter. These

patches are important to some of our rarest invertebrates, but these conditions cannot be attained safely through the application of low-severity prescribed burns. Light soil scarification can provide a surrogate for severe burns, but must be done carefully.

Invariably, the Pitch Pine/Scrub Oak systems formed on glacial deposits also support important aquifers supplying millions of gallons of freshwater to neighboring towns. This feature may serve to offset a generally negative public attitude toward Pitch Pine/Scrub Oak systems.

Species of Greatest Conservation Need in Pitch Pine/ Scrub Oak Systems

State Listing Status	Taxon Grouping	Scientific Name	Common Name	State Status
State-listed	Reptiles	<i>Terrapene carolina</i>	Eastern Box Turtle	SC
	Birds	<i>Circus cyaneus</i>	Northern Harrier	T
		<i>Asio otus</i>	Long-eared Owl	SC
		<i>Poocetes gramineus</i>	Vesper Sparrow	T
	Beetles	<i>Cicindela patruela</i>	Barrens Tiger Beetle	E
		<i>Nicrophorus americanus</i>	American Burying Beetle	E
	Lepidoptera	<i>Abagrotis nefascia</i>	Coastal Heathland Cutworm	SC
		<i>Acronicta albarufa</i>	Barrens Daggermoth	T
		<i>Anisota stigma</i>	Spiny Oakworm	SC
		<i>Apodrepanulatrix liberaria</i>	New Jersey Tea Inchworm	E
		<i>Callophrys irus</i>	Frosted Elfin	SC
		<i>Catocala herodias gerhardi</i>	Gerhard's Underwing	SC
		<i>Chaetagnalea cerata</i>	Waxed Sallow Moth	SC
		<i>Cicinnus melsheimeri</i>	Melsheimer's Sack Bearer	T
		<i>Cingilia catenaria</i>	Chain Dot Geometer	SC
		<i>Digrammia eremiata</i>	Three-lined Angle Moth	T
		<i>Eacles imperialis</i>	Imperial Moth	T
		<i>Erynnis persius persius</i>	Persius Duskywing	E
		<i>Euchlaena madusaria</i>	Sandplain Euchlaena	SC
		<i>Hemaris gracilis</i>	Slender Clearwing Sphinx Moth	SC
		<i>Hemileuca maia</i>	Barrens Buckmoth	SC
		<i>Hypomecis buchholzaria</i>	Buchholz's Gray	E
		<i>Itame sp. 1</i>	Pine Barrens Itame	SC
		<i>Lycia rachelae</i>	Twilight Moth	E
		<i>Lycia ypsilon</i>	Pine Barrens Lycia	T
		<i>Metarranthia apiciaria</i>	Barrens Metarranthia	E
		<i>Psectraglaea carnosia</i>	Pink Sallow Moth	SC
		<i>Ptichodis bistrigata</i>	Southern Ptichodis	T
		<i>Stenoporpia polygrammaria</i>	Faded Gray Geometer	T
		<i>Zale sp. 1</i>	Pine Barrens Zale	SC
		<i>Zanclognatha martha</i>	Pine Barrens Zanclognatha	T
Not Listed	Reptiles	<i>Coluber constrictor</i>	Black Racer	--
		<i>Heterodon platirhinos</i>	Eastern Hognose Snake	--
	Birds	<i>Caprimulgus vociferus</i>	Whip-poor-will	--
		<i>Colinus virginianus</i>	Northern Bobwhite	--
		<i>Dendroica discolor</i>	Prairie Warbler	--
		<i>Pipilo erythrophthalmus</i>	Eastern Towhee	--
		<i>Toxostoma rufum</i>	Brown Thrasher	--
	Lepidoptera	<i>Schizura apicalis</i>	Plain Schizura	--
		<i>Zale curema</i>	No common name	--

As can be seen from the table above, many rare lepidoptera in Massachusetts depend on pitch pine/scrub oak systems for habitat. These moth and butterfly species are not each found in all types of pitch pine/scrub oak, but are often specialists on a microhabitat, such as frost barrens, river corridors, or late-successional stands. In addition, many of the caterpillars of these species eat only pitch pine, or only scrub oak, or specialize on other larval hosts found only or mostly in pitch pine/scrub oak communities. Thus, to maintain metapopulations of these species over time, in a habitat dependent on disturbance, it is necessary to maintain large areas of pitch pine/scrub oak systems, in various stages of recovery from various kinds and severity of disturbances.

A number of vertebrates also depend on pitch pine/scrub oak communities, probably because of the open habitat structure it provides, rather than requiring pitch pine or scrub oak for sustenance. Thus, such early-successional birds as Prairie Warbler, Eastern Towhee, and Brown Thrasher can be found in both pitch pine/scrub oak and young forest/shrubland habitats, as defined in this document. Pitch pine/scrub oak systems which are particularly open, such as frost barrens, can support state-listed birds, such as Vesper Sparrow and Northern Harrier.

Threats to Pitch Pine/ Scrub Oak

Threats to Pitch Pine/Scrub Oak communities include:

- The exclusion of fire from fire-dependent habitats;
- Development and fragmentation of Pitch Pine/Scrub Oak areas;
- Groundwater contamination remediation activities;
- Introduction of non-specific biocontrol agents;
- Deer overpopulation, resulting in diminished food and nectar plants;
- Invasive exotic plants; and
- Habitat homogeneity.

Proposed Conservation Actions

Proposed actions aimed at conserving rare and uncommon Pitch Pine/Scrub Oak species in the future include, assuming adequate funding:

- Determining Species Habitat Polygons for each current occurrence of a state-listed Pitch Pine/Scrub Oak animal;
- Surveying for tiger beetles, moths, and butterflies associated with Pitch Pine/Scrub Oak, in areas that have been undersurveyed, to determine their range, abundance, and distribution in the state;
- Monitor sites that have been thoroughly surveyed in the past, to determine trends in populations of rare invertebrates;
- Protecting, managing and restoring Pitch Pine/Scrub Oak areas (and buffer areas when appropriate) supporting populations of rare and uncommon animals, using prescribed fire in most cases;
- Regulating and limiting the impacts of development on Pitch Pine/Scrub Oak areas used by state-listed animals;
- Researching the natural history of Pitch Pine/Scrub Oak animals;
- Restoring populations of Pitch Pine/Scrub Oak animals that were eliminated by insecticide spraying; and

- Educating/informing the public about the values of Pitch Pine/Scrub Oak habitats and the issues related to their conservation, through publications and other forms of public outreach.

Monitoring Conservation Action Effectiveness

The effectiveness of these proposed conservation actions will be monitored by assessing the:

- Number and percentage of the Species Habitat Polygon delineations used in regulatory reviews and land protection planning;
- Number and acreage of prescribed burns;
- Number and type of acres mowed;
- Number of research projects completed on Pitch Pine/Scrub Oak animal life histories;
- Number of surveys completed for undersurveyed Pitch Pine/Scrub Oak animals;
- Number of surveys completed of previously unsurveyed sites;
- Number of acres protected of Pitch Pine/Scrub Oak landscapes supporting rare and uncommon animals;
- Number of proposed Pitch Pine/Scrub Oak alterations reviewed and regulated by DFW each year; and
- Number of conservation actions modified and adapted, using the results of monitoring.

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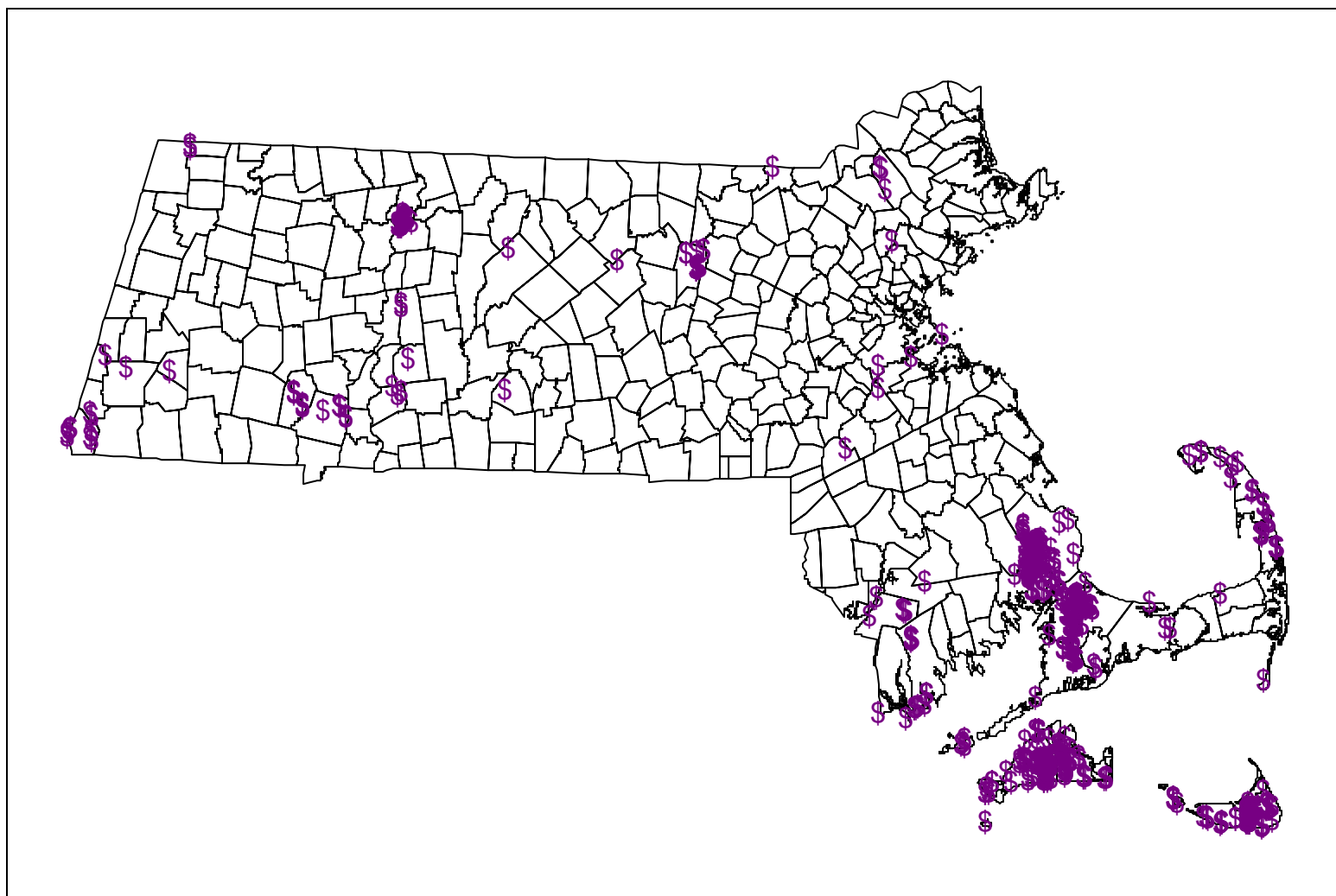


Figure 27: Locations of Pitch Pine/Scrub Oak Communities in Massachusetts.

B. Medium-scale Habitats

1. Small Streams

Habitat Description

Small streams are the first locations in the upper reaches of the watershed where rainfall, runoff, and groundwater come together to form a defined stream channel, typically with year-round flow. Small streams account for the majority of the linear stream miles in Massachusetts and connect catchments to subwatersheds and mainstem rivers. They accumulate and assimilate all upstream inputs, perturbations, and degradations and transmit them to reaches downstream. They are the capillaries of the aquatic circulatory system. It has long been realized that healthy small streams contribute to the integrity of the watershed by maintaining the soil, increasing infiltration, reducing the impacts of flooding, and maintaining summer base flow. Small streams are where the River Continuum Theory begins. River Continuum Theory works on several concepts to describe the metamorphosis of a narrow canopy-covered channel, often with fast flow, to a wider deeper channel with slower flows, which is naturally exposed to sunlight over most of its width. Consequently, the boundaries between small, medium and large streams are gradients, not absolutes.

Examples of small streams would be first- to third-order streams with a full canopy of mature trees and associated understory. The channel would most often be less than 30 feet wide and the drainage area could be less than 30 square miles. These streams often have naturally low fish diversity, low productivity and relatively high gradients. The substrates may be dominated by boulder and cobble in high-gradient watersheds like the Westfield, or gravel and sand in lower gradient watersheds like the Taunton. In most cases, small streams are dependent on groundwater for a high percentage of their annual flow and have food webs that are highly dependent on additions of nutrients from the surrounding vegetation.

Healthy small streams across the state would be expected to have varied fish communities. Coldwater streams can often support only a single species, often brook trout, or a few species in addition to brook trout, including slimy sculpin, blacknose dace, longnose dace, and others. In flowing waters that have water quality problems, blacknose dace will often dominate as they are more tolerant to water quality degradation than other species. Other small streams can be dominated by fish tolerant of warmer waters, like Creek Chubs or Fallfish. In almost all cases, healthy small streams would consist entirely of native fluvial (river) fish species.

Small streams experience a wide array of environmental conditions throughout the year. Summer flows are typically the lowest annual flows and can, at times, be near zero. Aquatic organisms that can find refuge during these extreme climate conditions can survive to repopulate. Spring flows are extreme in fluctuation and magnitude (excluding single events such as hurricanes which are not annual). These habitats depend on high flows to redistribute sediments and provide water to floodplain ecosystems. Many species key in on these high flows to initiate the reproductive cycle. Fall and winter flows are typically moderate compared to spring and summer, but the environmental conditions can still be extreme due to harsh New England weather. Very cold winters can cause the formation of anchor ice that can freeze stream channels solid. Fish will find small refugia in which to survive or move downstream to medium and large streams that will likely have more refugia. Small streams are relatively unstable (stochastic) environments with associated flora and fauna that have come to adapt and, in some

cases, rely on the harsh environment. It is the frequency and duration of these extreme events that will change as small streams are impacted by the threats listed below and it is the conservation actions also outlined below that will protect these resources.

Species of Greatest Conservation Need in Small Streams

State Listing Status	Taxon Grouping	Scientific Name	Common Name	State Status
State-listed	Fishes	<i>Lampetra appendix</i>	American Brook Lamprey	T
		<i>Couesius plumbeus</i>	Lake Chub	E
		<i>Phoxinus eos</i>	Northern Redbelly Dace	E
		<i>Catostomus catostomus</i>	Longnose Sucker	SC
	Amphibians	<i>Gyrinophilus porphyriticus</i>	Spring Salamander	SC
	Reptiles	<i>Clemmys insculpta</i>	Wood Turtle	SC
	Snails	<i>Pomatiopsis lapidaria</i>	Slender Walker	E
	Crustaceans	<i>Cambarus bartonii</i>	Appalachian Brook Crayfish	SC
	Odonates	<i>Boyeria grafiana</i>	Ocellated Darner	SC
		<i>Somatochlora elongata</i>	Ski-Tailed Emerald	SC
		<i>Somatochlora forcipata</i>	Forcipate Emerald	SC
		<i>Somatochlora georgiana</i>	Coppery Emerald	E
		<i>Somatochlora kennedyi</i>	Kennedy's Emerald	E
		<i>Somatochlora linearis</i>	Mocha Emerald	SC
	Lepidoptera	<i>Papaipema sulphurata</i>	Water-Willow Stem Borer	T
Not Listed	Fishes	<i>Cottus cognatus</i>	Slimy Sculpin	--
		<i>Rhinichthys atratulus</i>	Blacknose Dace	--
		<i>Rhinichthys cataractae</i>	Longnose Dace	--
		<i>Salmo salar</i>	Atlantic Salmon	--
		<i>Salvelinus fontinalis</i>	Brook Trout	--
		<i>Semotilus atromaculatus</i>	Creek Chub	--
		<i>Semotilus corporalis</i>	Fallfish	--
	Amphibians	<i>Rana pipiens</i>	Northern Leopard Frog	--
	Reptiles	<i>Thamnophis sauritus</i>	Eastern Ribbon Snake	--
	Birds	<i>Seiurus motacilla</i>	Louisiana Waterthrush	--
	Misc. Invertebrates	<i>Alloperla voinae</i>	A Stonefly	--
		<i>Hansonoperla appalachia</i>	Hanson's Appalachian Stonefly	--
		<i>Perlesta nitida</i>	A Stonefly	--
	Snails	<i>Physa vernalis</i>	Vernal Physa	--

Three of the state-listed fish of small streams are found only in localized portions of the state. American Brook Lamprey inhabit a few streams and small rivers in the southeastern part of Massachusetts, including on Martha's Vineyard. Lake Chub have been collected only from the main branches of the Westfield River, in western Massachusetts. Northern Redbelly Dace are currently known only from one small tributary to the Green River in Franklin County.

The small streams of the state west of the Quabbin Reservoir harbor a number of rare and uncommon species. Longnose Suckers, on the other hand, are fairly widely distributed in the colder rivers and streams of western Massachusetts. Appalachian Brook Crayfish are restricted to only the Hoosic River drainage, in northwestern Massachusetts, but they tend to be fairly common in the streams of that watershed. Spring Salamanders use the same cold, well-oxygenated streams, but are found through western Massachusetts and as far east as about

Worcester in central Massachusetts. Ocellated Darner dragonflies have mostly been found on the larger rivers (Westfield, Deerfield, Mill) in the Berkshire foothills, but they also venture up small streams.

While the breeding habitats of emerald dragonflies are not well known in Massachusetts, it is thought that four of them – Forcipate, Coppery, Kennedy's, and Mocha Emeralds – all breed in small, slow, boggy streams in central and eastern Massachusetts. Water-willow Stem Borer moths are restricted to southeastern Massachusetts, mostly in ponds and lakes, but where there is Water Willow (*Decodon verticillatus*) along small streams, the moth may also be found.

Slimy Sculpins are creatures of small, cold, free-flowing streams in Massachusetts. They are most abundant in the high gradient streams of the Berkshires and require high water quality as well as cold temperatures. They commonly associate with fast water and large substrates, like cobbles and boulders, and are often found even in cascading habitats. Although they represent a proportion of the fish in streams as large as the South River in Conway or the Sawmill River in Leverett, they thrive in even smaller streams. It is very conceivable that restoration efforts on mid- to large-size coldwater streams would enable slimy sculpin to recolonize those larger habitats.

The American Eel is a catadromous species, which spends most of its life in rivers, lakes and estuaries, but migrates to the ocean to spawn. Eels are capable of migrating several hundred kilometers from the ocean, taking up residence in small streams. These eels will remain there for the majority of their lives, for at least five and possibly as many as twenty years before returning to the sea to spawn and die.

Atlantic Salmon are anadromous, migrating from the ocean to freshwater specifically to reproduce. The Atlantic Salmon was extirpated from Massachusetts early in the 19th century, but restoration efforts are underway on both the Connecticut and Merrimack Rivers. All Atlantic Salmon spawning and rearing habitat is found in the tributaries, much of this habitat in small streams. Adults arrive at spawning sites in the fall and may spend several weeks there building spawning nests and defending spawning territories. After spawning the surviving adults migrate downstream. Several year-classes of juvenile salmon can be found year-round in small-stream rearing habitat.

Blacknose Dace and Longnose Dace are fluvial specialist species that require free-flowing water year-round to survive. Their habitat preferences are somewhat different in that Blacknose Dace like small pools or runs within the riffle/pool run matrix, and Longnose Dace will often be found in the faster water. Although not coldwater species, these fish are tolerant of a wide range of temperatures and are often associated with trout populations. Both species are often found within the same sampling effort. Blacknose Dace are a species relatively tolerant to water quality degradations; Longnose Dace are considered moderately tolerant. Monitoring the change in Blacknose Dace relative abundance from mere presence to dominance over coldwater species can help determine when water quality has declined. Further declines in water quantity, quality, or physical habitat cause even these tolerant species to be replaced by generalist species. Where flows are maintained but water quality declines, Blacknose Dace tend to dominate the fish community. Better water quality is indicated by a mix of these, and other, species. The free-

flowing habitats needed by these species have been highly degraded by impoundments, other physical habitat changes, and water quantity reduction.

Longnose Dace are similar in habitat use to Blacknose Dace but are more often associated with higher current velocities and have a lower tolerance for water quality degradation. Longnose Dace are also a fluvial specialist, as they require flowing water to meet all of their life history requirements. The high level of degradation to habitats used by Longnose Dace is the reason they are on the list of species in greatest need of conservation. The potential to restore habitat for Longnose (and Blacknose Dace) is also quite high.

Brook Trout are a coldwater species associated with small streams. The specific habitat needs within these streams are highly varied. Substrates from ledge to silt are all used to some extent by brook trout. They, like all fluvial specialists, require flows that mimic the natural hydrograph to meet their seasonal habitat needs. Brook Trout are also susceptible to degradations in water quality and have been impacted in many streams statewide. Physical habitat alteration, and changes to water quality and quantity continue to reduce and restrict the amount of habitat available to brook trout in Massachusetts. Some streams no longer support the coldwater fishery resources they once supported; other streams have lost fish abundances that once made them extraordinary fisheries. Brook Trout are not only an indicator species of cold, clean water, but also a marquee species that can focus efforts and garner support from a wide segment of the public. Although the public often has a limited understanding of aquatic organisms, many still understand the relevance of Brook Trout as representing our high quality resources and a goal for restoration.

Creek Chubs and Fallfish rely on flowing water for all life stages, most obviously for reproduction where clean sand and gravels is required for spawning. The free flowing habitats needed by these species have been highly degraded by impoundments, other physical habitat changes, and water quantity reduction.

Threats to Small Streams

As mentioned above, small streams are subject to wide fluctuations in habitat condition and contain flora and fauna that are adapted to deal with some amount of environmental extremity. The threats to small streams will cause changes to water quality, quantity, and physical habitat that will result in sometimes drastic increases in the frequency and duration of extreme events and a reduction in the ability of the habitat to provide refugia during the events.

Impacts from ever increasing amounts of impervious surface in the drainages of small streams can be a major threat to small streams and the aquatic communities they support. When the percentage of impervious surface in the watershed of a small stream reaches about 10% (Center for Watershed Protection 2000) negative impacts to natural stream morphology can be seen which reduce habitat for stream specialist species of fish and invertebrates. Likewise, negative impacts to water quality also begin to occur as a greater proportion of total flow must travel over impervious surfaces that may contain pollutants rather than natural ground cover. This also favors generalist species over specialists that would typically be found in these small streams.

Small streams are threatened by land use practices, fragmentation, and localized impacts of water withdrawal. Impairments to small streams, by the nature of the small watershed, are very local (with the notable exception being impacts of acid rain). If a small stream is impacted, the cause is very likely to be nearby. However simple these impacts may seem, they cause cumulative impacts with other downstream impacts and can have a severe impact laterally into floodplain and upland habitats, causing impacts to the species that use those habitats as well.

Land use practices that cause immediate deleterious effects to stream biota if Best Management Practices are not followed include forestry, farming, and urbanization. Fill and channelization both remove habitat and alter the function of small streams, making them less capable of supporting small stream biota. For example, channelization of a trout stream removes bends in streams and consequently the deep scour pools associated with them. These deep scour pools represent the only habitat that might be available in a low flow event or drought year. Without this habitat, a local reduction in the trout population translates into a larger scale extirpation. Channelization also impacts floodplain dynamics and soil hydrology, causing a ripple effect through the floodplain forest, shrub swamp, and upland forest habitats as well.

Fragmentation caused by dams, poorly designed culverts, road crossings and other barriers to fish passage make the habitat less suited to stream species and more suited to other species. Point source inputs can cause chemical or thermal zones impassible or lethal to fish and other less mobile species. Wells can dewater stream reaches, removing habitat and creating additional barriers to migration or fish movement.

In small streams, small perturbations can have acute local impacts. One poorly designed parking lot can release enough hot water from a summer thunderstorm to eliminate a coldwater fishery. Removal of riparian buffer strips causes increased exposure to sunlight and increases in temperatures. Unstable soils following removal of riparian cover result in channel modification and increased siltation, creating unstable habitats unsuitable to many of the species in greatest conservation need. Likewise, restorations carried out on small streams can also have the most immediate benefits.

Many species that inhabit small streams are tolerant of wide fluctuations found naturally, but cannot adapt to further degradations to already extreme fluctuations. Extreme low flows at natural recurrence intervals can cause population level effects in brook trout that take years to recover from. Water withdrawals that increase the low flow occurrence interval from 20 years to 3 years will result in populations that never recover. Likewise, exacerbating the extremity of low flows may result in population extirpations requiring more costly restoration efforts.

Dams on small streams cause several impacts to aquatic habitats. First, they create habitat unsuitable for native fluvial species and preferred by native and non-native pond species. Second, they stop the flow and transfer of energy, sediments, and nutrients. Water retained in small stream impoundments warms with increased exposure to sunlight and nutrients trapped in the impoundments become available for macrophyte or algal growth. All of these impacts translate into altered water quality downstream of the impoundment. Third, dams create barriers to fish passage that result in isolated populations of fluvial fish less able to cope with environmental extremes. Finally, most dams have no provision for minimum flow and, other

than leakage, provide no flow downstream in the summer months or other low flow periods. Low or no flow events then increase in frequency and magnitude and reduce the ability of the fish population to recover. All of these impacts will affect surrounding habitats as well.

Conservation Actions

Proposed actions aimed at conserving small stream habitats in the future include:

- Determining site-specific Species Habitat Polygons for each current occurrence of a state-listed small stream animal, to inform land protection and regulatory priorities and actions;
- Surveying for Forcinate Emerald, Coppery Emerald, Kennedy's Emerald, Mocha Emerald, Vernal Physa, and uncommon stoneflies of small streams to determine their range, abundance, and distribution in the state, as these species are undersurveyed in Massachusetts;
- Protecting land along small streams supporting populations of rare and uncommon animals;
- Conducting research into determining the priorities for restoration of small stream habitats by: 1) examining, in each watershed, the relative impacts caused by the threats listed above (Meso-Habitat Simulation Model (MesoHabSim)); and 2) developing Indexes of Biotic Integrity that are applicable to Massachusetts small streams;
- Provide methods for using biocriteria (Indexes of Biotic Integrity, Target Fish Communities) in water quality and quantity standards in Massachusetts;
- Identifying dam removal as a primary restoration tool and encouraging dam removal;
- Provide education to town conservation commissions to ensure proper enforcement and interpretation of the Wetland Protection Act;
- Increasing regulation by proposing expansion of the Rivers Protection Act;
- Quantify percent impervious surface;
- Provide information on percent impervious surface to local conservation commissions and planning boards for Atlantic Salmon stocked streams;
- Educate local decision makers about the negative impacts to streams from increases in impervious surface;
- Work with local planning agencies to reduce impacts from existing impervious surfaces using innovative technologies;
- Develop Index of Biotic Integrity Goals for small streams and rivers;
- Input existing statewide fish survey data into GIS format;
- Publish GIS maps of Atlantic Salmon stocked waters and other priority areas for educational purposes;
- Develop and publish GIS map of impervious surface cover and Target Fish Community Goals;
- Develop instream flow criteria to meet Target Fish Community Goals;
- Assess man-made stream fragmentation (for fish and wildlife purposes) due to transportation crossings;
- Regulating and limiting the impacts of development on small streams used by state-listed animals;
- Funding research on the natural history of small stream animals; and

- Educating/informing the public about the values of small stream habitats and the issues related to their conservation through agency publications and other forms of public outreach in order to instill public appreciation and understanding.

Monitoring Conservation Action Effectiveness

The effectiveness of these proposed conservation actions will be monitored by assessing the:

- Number and percentage of the Species Habitat Polygon delineations used in regulatory reviews and land protection planning;
- Number of research projects completed on small stream animal life histories;
- Number of surveys completed for undersurveyed small stream animals;
- Number of stream surveys and inventories completed for all fish species;
- Number of Indexes of Biotic Integrity created, appropriate to stream fish communities in Massachusetts;
- Number of priority watersheds set for restoration, using target fish community methodologies;
- Number of priorities set within the watershed for restoration, using Meso-Habitat Simulation Model (MesoHabSim) to develop the priorities.
- Number of acres of land protected, through fee acquisition or conservation restriction, along small streams supporting rare and uncommon animals;
- Number of proposed alterations to small streams reviewed and regulated by DFW each year;
- Number of conservation management permits (part of regulation of proposed developments) monitored, when those permits were issued by DFW for species of small streams; and
- Number of conservation actions modified and adapted, using the results of monitoring.

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2. Shrub Swamps

Habitat Description

Shrub swamps are shrub-dominated wetlands occurring on mineral or mucky mineral soils that are seasonally or temporarily flooded or saturated. They often occur as a successional area between freshwater marsh and forested swamp (Mitsch & Gosselink 2000) and occur in association with other wetland types in wetland complexes. These wetland tall shrub thickets are generally flooded in spring and early summer, with water levels dropping below the soil surface by late summer or early fall. Shrubs are perennial woody plants that have multiple stems and are generally less than 20 feet tall. There are usually at most scattered trees in shrub swamps, and the shrubs themselves produce at least 25% ground cover.

Called scrub-shrub wetlands, shrub-carr, alder thickets, and much more, shrub swamps are highly variable communities. The variability comes from effects of different climatic influences, topography, hydrologic regimes, amount and types of mineral enrichment in surface and groundwater, and particularly from the effects of past land use, all of which provides much confusion in interpretation of succession and direction. Shrub swamps can be dominated by one of, or a few of, or have a mixture of, the following shrub species: alders, sweet pepper-bush, buttonbush, winterberry, highbush blueberry, swamp azalea, maleberry, dogwoods, arrow-woods, meadowsweet, sweet gale, willows, poison sumac, and the non-native shrub European alder-buckthorn. Scattered red maple or gray birch saplings also occur. Shrub swamps in areas with circumneutral water are often dominated by spicebush. Willows are particularly common in swamps with more calcium-rich waters.

Buttonbush swamps are probably the wettest shrub swamps, staying permanently saturated year round. They occur on the edges of ponds and lakes or next to deep marshes; others are in smaller isolated depressions.

Shrub swamps are often found in areas of transition from either uplands or open water to peatland habitats. In areas with calcium-rich water where peat is not well developed, shrublands are particularly found in transitional areas. Many such areas are mosaics of patches of shrubs and more open sedges or cattails. Dense shrub zones often develop around the edges of bogs where mineral water influence keeps peat from developing.

Shrub swamps often succeed to forested swamps. In areas with active beaver populations, as dams are abandoned after beaver food resources (primarily deciduous/hardwood tree bark and twigs) become depleted, the impoundments drain, and succeed first to wet meadow, and then to shrubland and early successional forest. Beaver re-occupy such low lying sites, and continue the process of re-starting succession and the cycle of habitat modification. This process has been much reduced now that many low-lying areas are occupied by people who dislike the results of flooding. In pre-settlement times beaver were, and they continue to be, particularly active in maintaining streamside, or alluvial, shrub swamps.

Other areas that support shrub swamps include kettleholes that receive frost late enough in the spring to kill tree species. Many kettleholes, on the other hand, develop peat and support acidic

shrub fens or bogs (often with shrub swamps around the edges). Humans often maintain power line rights-of-ways in shrub cover; in such sites, wet areas become and are kept as shrub swamps.

Since shrubs often form dense thickets, the herbaceous layer of shrub swamps is often sparse and species-poor. A typical mixture of herbaceous species might include skunk cabbage, various ferns (especially cinnamon fern, sensitive fern, and royal fern), sedges, and sphagnum moss, with common arrowhead in wetter areas. Water-willow grows in the more open areas of shrub swamps.

Species of Greatest Conservation Need in Shrub Swamps

State Listing Status	Taxon Grouping	Scientific Name	Common Name	State Status
State-listed	Reptiles	<i>Clemmys guttata</i>	Spotted Turtle	SC
		<i>Clemmys muhlenbergii</i>	Bog Turtle	E
		<i>Emydoidea blandingii</i>	Blanding's Turtle	T
	Lepidoptera	<i>Catocala pretiosa pretiosa</i>	Precious Underwing Moth	E
		<i>Cingilia catenaria</i>	Chain Dot Geometer	SC
		<i>Hemaris gracilis</i>	Slender Clearwing Sphinx Moth	SC
		<i>Lithophane viridipallens</i>	Pale Green Pinion Moth	SC
		<i>Metarranthia pilosaria</i>	Coastal Swamp Metarranthia	SC
		<i>Papaipema stenocelis</i>	Chain Fern Borer	T
		<i>Papaipema sulphurata</i>	Water-Willow Stem Borer	T
Not Listed	Birds	<i>Anas rubripes</i>	American Black Duck	--
		<i>Buteo platypterus</i>	Broad-Winged Hawk	--
		<i>Butorides virescens</i>	Green Heron	--
		<i>Scolopax minor</i>	American Woodcock	--

Optimal Bog Turtle habitat is a mosaic of open habitat with rivulets beside tussocks, surrounded by successional stages of freshwater marsh and shrub swamp; the state-threatened Dion Skipper is also found in this habitat. Patches of calcareous sloping fens or calcareous seepage fens mixed with large areas of shrub swamp make good habitat for several rare turtles providing basking areas near thickets. Other mosaic wetlands with shrub swamps also provide good turtle habitat. Turtles utilize a variety of seasonal habitats, including multiple wetland habitat types, throughout their life cycle.

The larvae of the Pale Green Pinion Moth, a state-protected species, are found on several of these shrub species in acidic shrub swamps on the coastal plain. Another moth, the globally rare Precious Underwing, lays its eggs on the stems of red chokeberry, in shrub swamps within pitch pine/scrub oak barrens. Several species in the herbaceous layer of Shrub Swamps, including chain fern and water-willow, are larval hosts for rare Lepidoptera.

Shrub swamps with semi-permanent standing water, such as buttonbush swamps, provide good cover for a variety of ducks such as the American Black Duck and other waterfowl, including the Common Moorhen. Fish, such as banded sunfish and redbfin pickerel, use this cover type heavily when it is abutting ponds and low-gradient streams. Shrub swamps, and particularly the moats around them, often function as vernal pool habitat if the water remains standing for two to three months and lacks fish; these areas provide important amphibian breeding habitat. Particularly,

small depressions with buttonbush often function as vernal pools and support the amphibians typical of those habitats.

Shrub swamps provide important breeding habitat for many species of migratory birds, which make use of the dense thickets as protected nesting habitat. Mammals such as river otter, mink, muskrat, and beaver, also use shrub swamps as parts of their larger habitats. In the winter when the surface is frozen, browsers, including snowshoe hare, can have easy access to the shrubs and protection in the dense thickets. Many species of salamanders (some rare, others more common) breed in the open waters in and around shrub swamps, migrating upwards of 1000 feet or more into nearby upland forests where they spend much of their lives under forest floor debris and in underground mammal burrows. Turtles feed in and spend time in these same wet areas, sometimes eating the other species of conservation interest.

Threats to Shrub Swamps

The main threat to Shrub Swamps is alteration of the hydrological regime. Changes in either surface water or groundwater alter the flooding regime and the minerals and nutrients carried to shrub swamps, and can change the wetland status and the species involved. When shrub swamps occur adjacent to open water of lakes or streams, the shrubs are sometimes removed to allow or improve human access to the water for recreation.

Most types of shrub swamps are successional and need regular disturbance to be maintained in place, or they are maintained as parts of a larger area by disturbances moving over the landscape in time and space. Reduction in beaver activities reduces areas of early succession where shrub swamps develop.

Proposed Conservation Actions

Proposed actions aimed at conserving rare and uncommon shrub swamp species include, assuming adequate funding:

- Determining Species Habitat Polygons for each current occurrence of a state-listed shrub swamp animal;
- Locating large shrub swamps state-wide via aerial photo-interpretation, and field-surveying a selected percentage of these swamps for rare and uncommon animals;
- Locating smaller shrub swamps and field-surveying a subset for comparisons of use by rare and uncommon animals;
- Surveying for the lepidopterans of shrub swamps to determine their range, abundance, and distribution in the state, as these species are undersurveyed in Massachusetts;
- Protecting land in and around shrub swamps supporting populations of rare and uncommon animals;
- Regulating and limiting the impacts of development and water withdrawals on shrub swamps used by state-listed animals;
- Restoring and managing selected shrub swamps to maintain appropriate successional stages;
- Researching the natural history of shrub swamp animals; and
- Educating and informing the public about the values of shrub swamp habitats and the issues related to their conservation, through agency publications and other forms of public outreach, in order to instill public appreciation and understanding.

Monitoring Conservation Action Effectiveness

The effectiveness of these proposed conservation actions will be monitored by:

- Number and percentage of the Species Habitat Polygon delineations used in regulatory reviews and land protection planning;
- Number of research projects completed on shrub swamp animal life histories;
- Number of surveys completed for undersurveyed shrub swamp animals, and comparison of the varieties of types of shrub swamps as habitat for rare and uncommon animals;
- Acres of land protected in and around shrub swamps supporting rare and uncommon animals;
- Number of proposed shrub swamp alterations reviewed and regulated by DFW each year; and
- Number of conservation actions modified and adapted, using the results of monitoring.

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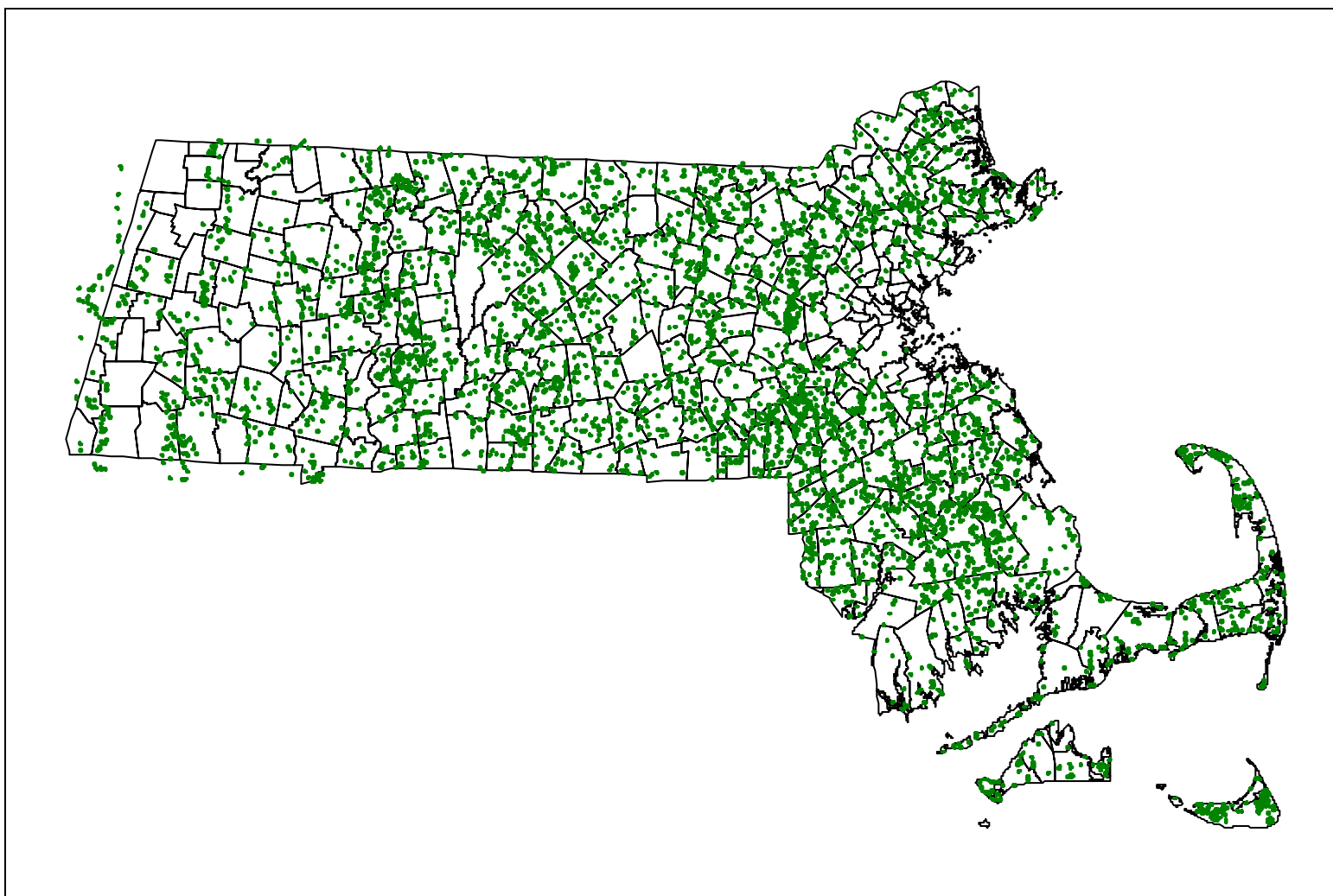


Figure 28: Shrub Swamps in Massachusetts, from MassGIS.
DEP wetland layers with additional information from the NWI and 25k Hydro data layers.

3. Forested Swamps

Habitat Description

Forested swamps are wetlands where trees dominate the vegetation and there is generally little buildup of peat. Soils are saturated for much of the growing season, often with standing water in the spring. Forested swamps are the most abundant types of all wetlands in the northeastern United States (Golet et al. 1993). They usually occur as patches or large patches within the surrounding upland matrix forest. They follow patterns of differences similar to the upland forests: in the northern hardwood zone of western and north-central Massachusetts, forested swamps are cold and often conifer dominated. In the warmer southern and eastern sections of the state and in the central hardwood area, forested swamps are dominated by red maple or Atlantic white cedar. See Figure 24: Massachusetts Ecological Provinces in the Upland Forest section, above. As habitat, swamps are strongly affected by the type of tree, evergreen or deciduous, that forms the canopy.

From the mountainous, northwestern part of the state at fairly high elevations, to sites at sea level along the coast, forested swamps include a wide variety of forest types and conditions. They occur in stream headwaters, behind floodplain forests, and in poorly drained basins. Spruce-fir Boreal Swamps, Hemlock Hardwood Swamps, and Atlantic White Cedar Swamps are coniferous, thus dark and acidic with year-round cover. Red Maple Swamps are the most common forested wetlands in Massachusetts. Red maples often occur with other hardwood tree species in particular situation. Calcareous seepage swamps are among the least common types of forested wetlands, and are rare natural communities in Massachusetts.

Forested swamps develop in poorly drained areas throughout the state. Depending on the physical setting, forested swamps receive water through surface runoff, groundwater inputs, or stream and lake overflow. The hydrogeologic setting is the primary determinant of water regime and the plant community structure and composition, and so of animal habitat. Although some swamps are on mineral soils, most have some amount of muck - shallow to thick organic layers overlying mineral sands/silts or even bedrock. Peat accumulation is minimal at most sites for most types of forested swamps, but some accumulation does occur. Many occurrences of forested swamps have some groundwater seepage at their edges, which increases species and habitat diversity.

Species of Greatest Conservation Need in Forested Swamps

State Listing Status	Taxon Grouping	Scientific Name	Common Name	State Status
State-listed	Reptiles	<i>Clemmys guttata</i>	Spotted Turtle	SC
	Birds	<i>Parula americana</i>	Northern Parula	T
	Mammals	<i>Sorex palustris</i>	Water Shrew	SC
	Crustaceans	<i>Synurella chamberlaini</i>	Coastal Swamp Amphipod	SC
	Lepidoptera	<i>Callophrys hesseli</i>	Hessel's Hairstreak	SC
		<i>Callophrys lanoraieensis</i>	Bog Elfin	T
		<i>Catocala pretiosa pretiosa</i>	Precious Underwing Moth	E
		<i>Lithophane viridipallens</i>	Pale Green Pinion Moth	SC
		<i>Pieris oleracea</i>	Eastern Veined White	T
Not Listed	Reptiles	<i>Thamnophis sauritus</i>	Eastern Ribbon Snake	--

State Listing Status	Taxon Grouping	Scientific Name	Common Name	State Status
	Birds	<i>Anas rubripes</i>	American Black Duck	--
		<i>Buteo platypterus</i>	Broad-Winged Hawk	--
		<i>Butorides virescens</i>	Green Heron	--
		<i>Wilsonia canadensis</i>	Canada Warbler	--
		<i>Zonotrichia albicollis</i>	White-throated Sparrow	--

Evergreen swamps and deciduous swamps provide quite different habitats, both in the tree canopy and on the ground. Evergreen trees provide year-round cover, providing protective habitat for animals in the winter. They often have a less dense shrub layer than deciduous swamp forests. They also tend to be more acidic, and have fewer amphibians in them than deciduous swamps. However, Four-toed Salamanders breed in hummocks of grasses, sedges, and mosses, but generally prefer sphagnum moss in evergreen and deciduous swamps. Song birds (passerine species) of swamp forest are similar to the birds of structurally similar upland forests; their choice of breeding territories is not particularly affected by the trees in which they nest and feed being in swamps. Many bird species use swamps extensively during migration or for wintering (Golet et al. 1993). The dense shrub layers of many deciduous swamps provide excellent nesting locations for birds of thickets. The state-rare Northern Parula nests only where there is abundant beard moss (*Usnea* lichen), which in Massachusetts restricts it to a few Atlantic white cedar swamps. Ground-dwelling species, such as reptiles and amphibians, are affected by the presence of wet or moist soils in swamps, and tend to be more common in them than in uplands, at least for breeding and feeding (Mitsch & Gosslelink, 2000). Most forested swamps that have two or three months of ponding and lack fish can function as vernal pools; these sections of the swamps provide important amphibian breeding habitat for rare and common species alike.

Many wide-ranging wildlife species use swamp forests as part of their habitats. Bears use wetlands throughout the spring and early summer, especially when most food is unavailable but skunk cabbage has emerged. Some fruits, such as highbush blueberries, are eaten when they appear in the summer as a seasonal part of a diet. Other fruits and seeds, such as winterberry, provide food through the winter. Shrubs may be browsed when the ground is frozen and they are most accessible, with more easily accessed upland browse used in the wetter seasons. The amount of escape cover and water availability makes swamps important habitat for many species of small mammals (Golet et al. 1993).

Most of the rare species that occur in swamps are found in one or a few types of swamp forest, not in all the variants. Hessel's Hairstreak is a rare butterfly whose larvae feed in the canopy of Atlantic white cedar, eating only the cedar. The species is found most often in large Atlantic white cedar swamps with boggy openings and is restricted to the southeastern part of the state as a result. In Massachusetts, the Precious Underwing Moth is restricted to a single headwater swamp within pitch pine/scrub oak barrens, where it lays eggs on red chokeberry. The Eastern Veined White butterfly is found in openings and along edges of moist deciduous or mixed woodlands. The Bog Elfin is a butterfly that inhabits black spruce bogs, where larvae feed exclusively on black spruce.

All ages of Spotted Turtles use all types of wetlands, including forested swamps, for overwintering, nesting, feeding, shelter, and estivating (Fowle, 2001). The more common

Eastern Ribbon Snake primarily eats fish and amphibians, and is often in or near vegetative cover at the edges of open water. A shrub layer is important part of their habitat because they climb into low vegetation, but seldom into the tree canopy (NatureServe, 2005). They make use of a matrix of habitats and hibernate in uplands.

Threats to Forested Swamps

Changes in water quality and quantity threaten all wetlands. Changes in chemistry will alter herbaceous, and eventually tree, species, changing habitat for birds and browsers, such as deer and rabbits. Conversion to agriculture, filling for development and highway construction, and upland development adjacent to swamps all impact normal hydrology and geochemistry, and reduce the total acres of swamp land in the state. Alterations of water chemistry from road and farm runoff - in particular the accumulation of road salts - are additional threats to forested swamps. Intense logging will remove trees, drastically changing the habitat. There are times when intense logging might be necessary to re-establish particular forest types, such as Atlantic white cedar, where partial cuts allow competitors like red maple to replace the cedar. Less intense logging that removes the forest canopy in the immediate vicinity of seasonal pools can degrade wetland habitat quality by negatively affecting amphibians, which then affects all species that feed on them. The eggs and larvae of amphibians that breed in seasonal pools are an important food source for Spotted Turtles (Fowle, 2001).

The acreage of most types of forested wetland has diminished from presettlement times. Until the Massachusetts Wetlands Protection Act was passed in 1972, filling wetlands was common. Some filling continues, and is a continual threat to all types of wetlands. Roads that go through wetlands act as dams, change the quantity of water on either side, and fragment the habitat, as well as becoming a hazard for animals crossing them.

Water level disturbance can lead to the invasion by non-native plants, including the aggressive exotics purple loosestrife (*Lythrum salicaria*), Tatarian honeysuckle (*Lonicera tatarica*), and Morrow's honeysuckle (*Lonicera morrowii*). Phragmites (*Phragmites australis*) is also an aggressive exotic in disturbed forested swamps.

Heavy browsing by deer has been shown to prevent cedar reproduction after fires and logging (NatureServe, 2005). Particular tree species can be preferentially selected for browsing, with a resulting change in canopy structure when deer populations are high.

Proposed Conservation Actions

Proposed actions aimed at conserving rare and uncommon forested swamp species in the future include, assuming adequate funding:

- Determining Species Habitat Polygons for each current occurrence of a state-listed forested swamp animal;
- Locating large forested swamps state-wide via aerial photo interpretation, mapping them, and field-surveying a selected percentage of these swamps for rare and uncommon animals;
- Surveying for Water Shrew and Coastal Swamp Amphipod to determine their range, abundance, and distribution in the state, as these species are undersurveyed in Massachusetts;

- Examining the results of the Massachusetts Reptile and Amphibian Atlas to determine the status of Eastern Ribbon Snake;
- Supporting a focused survey of Four-toed Salamanders to examine population sizes in selected forested swamps and circumscribe populations in protected forested swamps;
- Protecting land in and around forested swamps supporting populations of rare and uncommon animals;
- Regulating and limiting the impacts of development, chemical inputs, and changes in water quality and quantity on forested swamps used by state-listed animals;
- Analyzing the results of planned forest harvests in forested swamps, to document effects on rare and uncommon species;
- Researching the natural history of forested swamp animals; and
- Educating and informing the public about the values of forested swamp habitats and the issues related to their conservation, through agency publications and other forms of public outreach.

Monitoring Conservation Action Effectiveness

The effectiveness of these proposed conservation actions will be monitored by assessing the:

- Number and percentage of the Species Habitat Polygon delineations used in regulatory reviews and land protection planning;
- Number of research projects completed on forested swamp animal life histories;
- Number of surveys completed for undersurveyed forested swamp animals;
- Acres of land protected in forested swamp supporting rare and uncommon animals;
- Number of proposed forested swamp alterations reviewed and regulated by DFW each year; and
- Number of conservation actions modified and adapted, using the results of monitoring.

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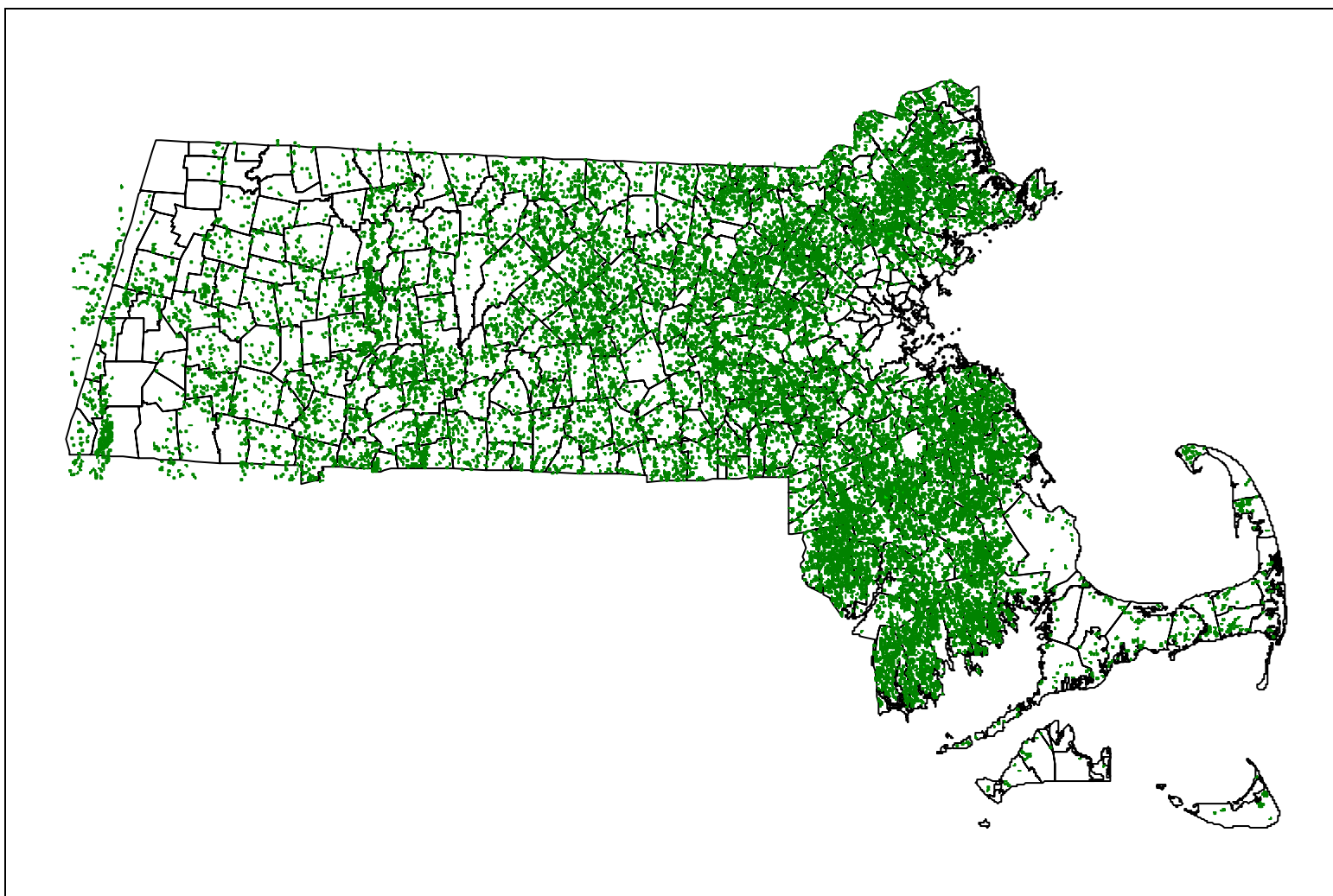


Figure 29: Forested Swamps in Massachusetts, from MassGIS.
DEP wetland layers with additional information from the NWI and 25k Hydro data layers.

4. Lakes and Ponds

Habitat Description

Massachusetts has been blessed with nearly 3,000 named lakes and ponds, totaling over 150,000 surface acres. Many of our lakes were naturally formed over 10,000 years ago during the retreat of the last ice age. These include the typical kettlehole ponds on the Cape. They provide many of the water needs, both consumptive and recreational, for many communities. Their main function, however, is habitat for a wide variety of fish and wildlife. Healthy lakes, in terms of both water quality and quantity and critical wildlife habitat, are essential to maintaining a balanced ecosystem. Many lakes are positioned as the headwaters to streams and rivers, making them a crucial link in the overall aquatic community.

While Massachusetts has a few large reservoirs, such as the 25,000-acre Quabbin Reservoir, over half of our named waters are less than 10 acres. These waters less than 10 acres in turn represent more than 90% of the total surface acres of lakes and ponds in the state. Massachusetts also has relatively few deep lakes. These lakes are significant in that they remain cool and oxygenated enough throughout the summer to support both cold and warmwater fish species. Most of our waters are relatively shallow and warm up during the summer months to the point where they have a limited ability to support some species. All lakes, regardless of how they were formed or their size and depth, go through a natural ageing process called eutrophication. All lakes begin as relatively sterile bowls of water, then age as they become nutrient-rich to ultimately become wet meadows. This process normally takes thousands of years; however, it can be greatly accelerated through human activity.

Species of Greatest Conservation Need in Lakes & Ponds

State Listing Status	Taxon Grouping	Scientific Name	Common Name	State Status
State-listed	Fishes	<i>Notropis bifrenatus</i>	Bridle Shiner	SC
		<i>Gasterosteus aculeatus</i>	Threespine Stickleback	T
	Reptiles	<i>Pseudemys rubriventris pop 1</i>	Northern Red-Bellied Cooter	E
	Birds	<i>Gavia immer</i>	Common Loon	SC
		<i>Podilymbus podiceps</i>	Pied-Billed Grebe	E
		<i>Haliaeetus leucocephalus</i>	Bald Eagle	E
	Mammals	<i>Sorex palustris</i>	Water Shrew	SC
	Misc.	<i>Spongilla aspinosa</i>	Smooth Branched Sponge	SC
	Invertebrates	<i>Macrobdella sestertia</i>	New England Medicinal Leech	SC
	Snails	<i>Ferrissia walkeri</i>	Walker's Limpet	SC
		<i>Pyrgulopsis lustrica</i>	Pilsbry's Spire Snail	E
		<i>Valvata sincera</i>	Boreal Turret Snail	E
	Mussels	<i>Alasmidonta undulata</i>	Triangle Floater	SC
		<i>Leptodea ochracea</i>	Tidewater Mucket	SC
		<i>Ligumia nasuta</i>	Eastern Pondmussel	SC
	Odonates	<i>Aeshna mutata</i>	Spatterdock Darner	SC
		<i>Anax longipes</i>	Comet Darner	SC
		<i>Neurocordulia obsoleta</i>	Umber Shadowdragon	SC
		<i>Enallagma carunculatum</i>	Tule Bluet	SC
		<i>Enallagma daeckii</i>	Attenuated Bluet	SC
		<i>Enallagma laterale</i>	New England Bluet	SC

State Listing Status	Taxon Grouping	Scientific Name	Common Name	State Status
Not Listed	Lepidoptera	<i>Enallagma pictum</i>	Scarlet Bluet	T
		<i>Enallagma recurvatum</i>	Pine Barrens Bluet	T
		<i>Papaipema sulphurata</i>	Water-Willow Stem Borer	T
	Fishes	<i>Alosa pseudoharengus</i>	Alewife	--
		<i>Anguilla rostrata</i>	American Eel	--
		<i>Catostomus commersoni</i>	White Sucker	--
		<i>Luxilus cornutus</i>	Common Shiner	--
		<i>Enneacanthus obesus</i>	Banded Sunfish	--
		<i>Etheostoma fusiforme</i>	Swamp Darter	--
	Amphibians	<i>Rana pipiens</i>	Northern Leopard Frog	--
	Reptiles	<i>Thamnophis sauritus</i>	Eastern Ribbon Snake	--
	Birds	<i>Anas rubripes</i>	American Black Duck	--
	Misc. Invertebrates	<i>Corvomeyenya everetti</i>	Mount Everett Pond Sponge	--
	Snails	<i>Physa vernalis</i>	Vernal Physa	--
	Odonates	<i>Enallagma minusculum</i>	Little Bluet	--

A long list of species of greatest conservation need inhabit lakes and ponds in Massachusetts. Some of these species – Threespine Stickleback, Smooth Branched Sponge, New England Medicinal Leech, Walker’s Limpet, Pilsbry’s Spire Snail, Boreal Turret Snail, and Mount Everett Pond Sponge – are found only in one to a very few sites across the state, while others – Bald Eagle, Bridle Shiner, Common Shiner, and American Black Duck, for example – can be found in many locations across the state, but their population numbers are or were declining. Northern Red-bellied Cooters and Water-willow Stem Borer moths are virtually endemic to Massachusetts. Other species are found only in coastal plain ponds (discussed elsewhere) and ponds structurally similar to these.

Threats to Lakes & Ponds

Accelerated eutrophication due to watershed activities is one of the greatest threats to our lakes. These activities can include nutrient-rich effluents from sewage treatment plants, agricultural run-off, stormwater run-off from impervious surfaces, leaching from septic systems, and soil erosion from construction and timbering activities. Currently, hundreds of waters in Massachusetts do not meet their designated water quality standards. This accelerated eutrophication can contribute to an increase in the abundance of aquatic vegetation, increased turbidity, decreased dissolved oxygen levels, and increased sedimentation which ultimately decreases the depth of a lake. Most Massachusetts lakes are particularly susceptible to accelerated eutrophication due to their small watersheds. The introduction of non-native invasive plants that can create monocultures and eliminate open water habitat is another major threat to all of our lakes. As with aquatic plants, the introduction of non-native animals such as zebra mussels or snakeheads can have a devastating effect on the aquatic ecosystem.

Conservation Actions

Proposed actions aimed at conserving lake & pond habitats in the future include:

- Determining site-specific Species Habitat Polygons for each current occurrence of a state-listed lake and pond animal, to inform land protection and regulatory priorities and actions;
- Continuing to survey lakes and ponds for fish species;

- Surveying for Water Shrew, Smooth Branched Sponge, New England Medicinal Leech, rare freshwater snails, Spatterdock Darner, Tule, Attenuated, and Little Bluets, Mt. Everett Pond Sponge, and Vernal Physa to determine their range, abundance, and distribution in the state, as these species are undersurveyed in Massachusetts;
- Protecting land around lakes and ponds supporting populations of rare and uncommon animals;
- Coordinating with the Massachusetts Department of Environmental Protection to support the attainment of targeted water quality standards for all lakes and ponds;
- Regulating and limiting the impacts of development on lakes and ponds used by state-listed animals;
- Reviewing all regulated construction projects to assure proper Best Management Practices for erosion and sedimentation control and other required conditions are adhered to;
- Identifying and understanding the impacts of invasive plants and animals;
- Educate the public as to the dangers of releasing non-native plants and animals into lakes and ponds;
- Educate/inform the public about the values of these habitats and the issues related to their conservation, through agency publications and other forms of public outreach, in order to instill public appreciation and understanding.

Monitoring Conservation Action Effectiveness

The effectiveness of these proposed conservation actions will be monitored by assessing the:

- Number and percentage of the Species Habitat Polygon delineations used in regulatory reviews and land protection planning;
- Number of lake and pond surveys and inventories completed;
- Number of surveys completed for undersurveyed lake and pond animals;
- Acres of land protected, through fee acquisition or conservation restriction, around lakes and ponds supporting rare and uncommon animals;
- Number of proposed lake and pond alterations reviewed and regulated by DFW each year;
- Number of conservation management permits (part of regulation of proposed developments) monitored, when those permits were issued by DFW for lake and pond species; and
- Number of conservation actions modified and adapted, using the results of monitoring.

5. Salt Marsh

Habitat Description

Located between the high spring tide and mean tide levels of protected coastal shores, salt marshes and the adjacent tidal flats comprise one of the most productive ecosystems on earth. In spite of the stresses of wide variations in temperature, level of salinity, and degree of inundation, the salt-tolerant vegetation of the salt marsh community provides the basis of the complex food chains in both estuarine and marine environments. In addition, salt marshes provide habitat for various species of wildlife--including migrating and overwintering waterfowl and shorebirds and the young of many species of marine organisms. In the northeastern United States, salt marsh communities are dominated by two species of perennial, emergent grasses that are adapted to growth in salty soils--Saltmarsh Cordgrass and Saltmeadow Cordgrass. While these dominant species give the community a deceptively simple, grassland-like appearance, salt marsh systems are heterogeneous and provide a variety of habitats. Low marshes flood with salt water in every tide and are only exposed for brief periods during low tide. High marshes, on the other hand, are submerged only during the highest tides. Shrubby areas, salt shrub, are on slightly higher areas within the marsh or towards the upper edges. Slightly lower areas within the marshes can form salt pannes where seawater is held as tides recede. When the salt water evaporates, a salt crust is left on bare ground: as open areas in the marsh, pannes are important to migrating waterfowl.

Species of Greatest Conservation Need in Salt Marshes

State Listing Status	Taxon Grouping	Scientific Name	Common Name	State Status
State-listed	Reptiles	<i>Malaclemys terrapin</i>	Diamondback Terrapin	T
	Birds	<i>Sterna dougallii</i>	Roseate Tern	E
		<i>Sterna hirundo</i>	Common Tern	SC
		<i>Sterna paradisaea</i>	Arctic Tern	SC
		<i>Sterna antillarum</i>	Least Tern	SC
		<i>Tyto alba</i>	Barn Owl	SC
		<i>Asio flammeus</i>	Short-eared Owl	E
	Snails	<i>Cincinnatia winkleyi</i>	New England Siltsnail	SC
		<i>Littoridinops tenuipes</i>	Coastal Marsh Snail	SC
		<i>Vertigo perryi</i>	Olive Vertigo	SC
	Lepidoptera	<i>Bagisara rectifascia</i>	Straight Lined Mallow Moth	SC
		<i>Neoligia semicana</i>	Northern Brocade Moth	SC
		<i>Spartiniphaga inops</i>	Spartina Borer	SC
Not Listed	Birds	<i>Ammodramus caudacutus</i>	Saltmarsh Sharp-tailed Sparrow	--
		<i>Ammodramus maritimus</i>	Seaside Sparrow	--
		<i>Anas rubripes</i>	American Black Duck	--
		<i>Egretta thula</i>	Snowy Egret	--
		<i>Nycticorax nycticorax</i>	Black-crowned Night-Heron	--
		<i>Sturnella magna</i>	Eastern Meadowlark	--

Many species of birds use salt marshes in all the seasons. In particular, many shorebirds, including American Oystercatcher, Willet, Killdeer, and Spotted Sandpiper, forage there. In summer, Snowy Egrets and Glossy Ibis feed in pools at low tide. American Black Ducks also frequent the salt marsh. A few, such as Seaside Sparrow and Saltmarsh Sharp-tailed Sparrow,

nest there as well, as do occasional Least Bitterns and Common Terns. In fall and winter, Short-eared Owls, Snowy Owls, and Northern Harrier hunt in salt marshes. All the tern species use salt marshes for loafing (resting), and salt marshes provide important cover for mobile young.

In fact, many animals use the abundant resources of the salt marsh. Marine species such as polychaete worms, snails, small crustaceans, and filter-feeding mussels dwell in the low marsh. Various insects graze on the vegetation or spend their larval stage in the mud. The larvae of several state-listed moths are specialists on plant species that predominantly occur in salt marshes (in Massachusetts), and so are restricted to those habitats. Spartina Borer Moth larvae live in the prairie cordgrass of brackish and freshwater marshes, and Straight Lined Mallow Moth larvae feed primarily on rose mallow along the margin of the salt marsh. With the incoming tide, fish and crabs move in to feed. Few mammals are resident in salt marshes, but raccoons and meadow voles use them, retreating to drier areas during high tides.

Tidal creeks--which facilitate the flooding and drainage of the marsh--have their own distinct flora and fauna. Fiddler crabs are invertebrates often found in salt marsh creeks. Common fish in tidal creeks include Mummichog, Four-spined Stickle-back, and Striped Killifish.

Diamondback terrapins use salt marshes and mud flats that border quiet salty or brackish waters, and nest in nearby open and dry sandy areas. They hibernate by burying into the substrate of nearby estuary channels, among other sheltered wetlands, during the winter months. Salt marshes themselves are critical habitat for juvenile terrapins.

Terns are colonial nesters on ocean beaches on islands and spits, areas often in or near salt marshes. Least and Common Terns nest in high spots within salt marshes. Roseate Terns nest adjacent to salt marshes. Young, mobile terns of all the species find important cover in salt marshes. Grassy habitats, including salt marshes, are used by Barn Owls and Short-eared Owls foraging for small mammals and other prey.

Threats to Salt Marshes

Since the arrival of the first Europeans, Massachusetts has lost a large portion of its salt marsh habitat. The Boston area was originally the site of an extensive salt marsh, most of which was destroyed by dredging and filling of the Back Bay. Between the end of World War II and the mid-1970s, Massachusetts lost approximately 20,000 acres of salt marsh — a third of the total acreage it had at the beginning of this period. Fortunately, little development now occurs in salt marsh areas.

Current threats to salt marshes include some development, dredging for docks and marinas, and ditching for mosquito control — all of which change the water drainage patterns, and hence the viability of the community and the habitat for the animals.

Invasive species are another important threat to salt marshes, especially where the normal tidal influence has been altered. The upland edges of many salt marshes have dense areas of the invasive variant of common reed (*Phragmites australis*), as do brackish tidal marshes in several rivers. Purple loosestrife (*Lythrum salicaria*) is established in some of the fresher parts of many salt marsh systems, adding a shrub-like aspect to the habitat that previously would not have been

present. While this increases habitats for some abundant upland species, specialists in the grass-rush dominated marshes lose habitat. The increasingly invasive Mute Swan is becoming more abundant and displacing native species from salt ponds surrounded by salt marsh habitat.

Proposed Conservation Actions

Proposed actions aimed at conserving rare and uncommon salt marsh species in the future include, assuming adequate funding:

- Determining Species Habitat Polygons for each current occurrence of a state-listed animal found in salt marshes;
- Continuing intensive management of human activities in or near salt marshes supporting breeding colonies of terns;
- Surveying for rare salt marsh invertebrates to determine their range, abundance, and distribution in the state, as these species are undersurveyed in Massachusetts;
- Surveying breeding populations of uncommon salt marsh birds to determine their distribution and abundance in the state, tracking changes in these populations over time, and determining the need for protection of these breeding populations under the state Endangered Species Act;
- Determining the effects of invasive plants and animals on habitats of native species, and evaluating and implementing possible management or restoration actions as necessary;
- Protecting salt marshes supporting populations of rare and uncommon animals, as well as adjacent uplands buffering salt marshes;
- Regulating and limiting the impacts of development on salt marshes used by state-listed animals;
- Researching the natural history of animals of salt marshes;
- Identifying dam, ditch, and culvert removal as primary restoration tools and encouraging removal of dams, ditches, and culverts, with the aim of returning hydrology to pre-degradation levels; and
- Educating and informing the public about the value of salt marsh habitats and the issues related to their conservation, through agency publications and other forms of public outreach, in order to instill public appreciation and understanding

Monitoring Conservation Action Effectiveness

The effectiveness of these proposed conservation actions will be monitored by assessing the:

- Number and percentage of the Species Habitat Polygon delineations used in regulatory reviews and land protection planning;
- Number of research projects completed on salt marsh animal life histories;
- Number of surveys completed for undersurveyed salt marsh animals;
- Acres of land protected in and around salt marshes supporting rare and uncommon animals;
- Number of proposed salt marsh alterations reviewed and regulated by DFW each year;
- Number of dam, ditch, and culvert removals yearly, to benefit salt marshes;
- Acres of salt marsh surveyed for invasive species and evaluation of their threats to habitats of native species; and
- Number of conservation actions modified and adapted, using the results of monitoring.

References

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- Swain, P. C., and J. B. Kearsley. 2001. *Classification of the Natural Communities of Massachusetts*. Draft Version 1.3. Natural Heritage & Endangered Species Program, Massachusetts Division of Fisheries and Wildlife, Westborough, Massachusetts.

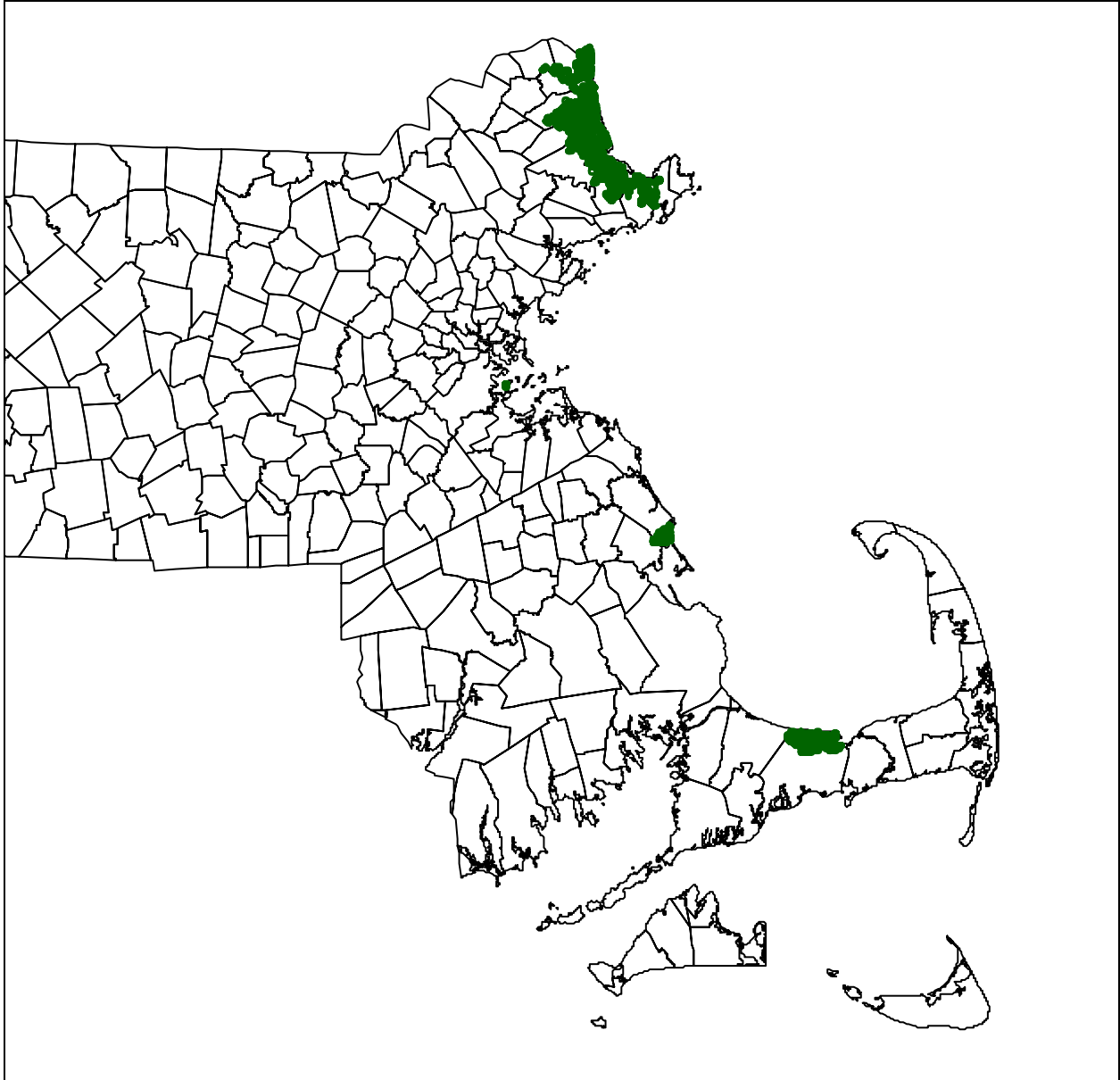


Figure 30: Extensive Areas of Salt Marsh in Massachusetts.

6. Coastal Dunes, Beaches, and Small Islands

Habitat Description

Much of the coastline of Massachusetts — the second-longest coastline in the eastern United States — is sandy beaches and dune systems. In some places, these form barrier beaches, with extensive estuaries and salt marshes inland of the dunes. Examples of these are Plum Island, Sandy Neck, and the outer Cape Cod. In some places, high steep cliffs of clay, sand, or gravel line the inland edge of the outer beach. In addition to the very large islands of Nantucket and Martha's Vineyard, there are many other small-to-large rocky or sandy islands off the coast in numerous places, notably the Elizabeth Islands, the Boston Harbor islands, and islands off the North Shore. All these habitats support a variety of rare and uncommon animals, most specialized for life only in these areas.

Maritime Beach Strand Community

This is the classic upper beach, familiar to all who have visited the coast. Sparsely vegetated, this long, narrow natural community lies between the wrack line and low tide, saturated or subaqueous zone of and high tide and the foredunes. Usually part of a barrier beach system, seaward of the dunes, this part of the beach is above the daily high tides and is highly dynamic. However, beach strands are subject to overwash during storms and spring tides and are continuously reshaped by wind and water. Beach strands are often separated from the mainland by lagoons, estuaries and great salt ponds.

Maritime Erosional Cliff Community

These sand or and clay sea cliffs are composed of glacially derived sands, cobbles and boulders eroded by the sea, especially during storms. Active erosion of the cliffs by wind and wave dictate slope and stability at any given moment. While vegetation is generally very sparse on these cliffs, it is most diverse where freshwater seepage emerges through the bluff and in portions with low relief.

Maritime Dune Community

This is the classic community of sand dunes, dominated by dune grass (*Ammophila breviligulata*) with patches of herbaceous plants interspersed with areas of bare sand and shrubs. In well-developed systems, interdunal swales occur. The maritime dune community occurs on windswept dunes, within the salt spray zone, often landward of the Beach Strand Community and grading into shrubland, heathland or woodlands on the more sheltered back dunes. Dunes are deposited by wind, water action or and storm overwash. The propensity of dunes to move over time, because of wind and wave action, is an important component of this habitat.

See Swain and Kearsley (2000) for more detail on these three natural communities.

Small islands off the Massachusetts coast are varied in their composition. Some are small sandy or cobbly bars, just barely above high tide. Some are resistant bedrock, with steep rock cliffs dropping directly into the ocean. Some harbor short, wind-twisted trees, but many are grassy or shrubby, in part due to wind and salt spray, but also because many islands were cleared of timber and used for grazing or agriculture during colonization historically. Often, these cleared islands have not yet and may never revert to woodlands.

Species of Greatest Conservation Need in Coastal Dunes, Beaches, and Small Islands

State Listing Status	Taxon Grouping	Scientific Name	Common Name	State Status
State-listed	Birds	<i>Oceanodroma leucorhoa</i>	Leach's Storm-Petrel	E
		<i>Charadrius melodus</i>	Piping Plover	T
		<i>Sterna dougallii</i>	Roseate Tern	E
		<i>Sterna hirundo</i>	Common Tern	SC
		<i>Sterna paradisaea</i>	Arctic Tern	SC
		<i>Sterna antillarum</i>	Least Tern	SC
	Beetles	<i>Cicindela dorsalis dorsalis</i>	Northeastern Beach Tiger Beetle	E
		<i>Cicindela limbalis</i>	Bank Tiger Beetle	SC
	Lepidoptera	<i>Bagisara rectifascia</i>	Straight Lined Mallow Moth	SC
		<i>Cingilia catenaria</i>	Chain Dot Geometer	SC
		<i>Oncocnemis riparia</i>	Dune Noctuid Moth	SC
Not Listed	Birds	<i>Arenaria interpres</i>	Ruddy Turnstone	--
		<i>Calidris alba</i>	Sanderling	--
		<i>Calidris canutus</i>	Red Knot	--
		<i>Egretta thula</i>	Snowy Egret	--
		<i>Haematopus palliatus</i>	American Oystercatcher	--
		<i>Larus atricilla</i>	Laughing Gull	--
		<i>Limnodromus griseus</i>	Short-billed Dowitcher	--
		<i>Numenius borealis</i>	Eskimo Curlew	--
		<i>Numenius phaeopus</i>	Whimbrel	--
		<i>Nycticorax nycticorax</i>	Black-crowned Night-Heron	--
		<i>Somateria mollissima</i>	Common Eider	--
	Mammals	<i>Microtus breweri</i>	Beach Vole	--

Several species of shorebirds are beach specialists, nesting or foraging on beach strands, including Least Tern, Piping Plover, and American Oystercatcher. Beach strands are important shorebird staging areas: migratory shorebirds use barrier beach systems, including the beach strand community, for resting, feeding, and congregating before and during migration. Merlins (*Falco columbarius*) and Peregrine Falcons (*Falco peregrinus*) forage on beaches and islands during migration. Few mammals use the beaches for foraging or denning, except for hunting, especially by mid-sized predators, such as red fox (*Vulpes vulpes*), striped skunk (*Mephitis mephitis*), raccoon (*Procyon lotor*) and coyote (*Canis latrans*). Gray seals (*Halichoerus grypus*) bear their young and rest on the beach; beach resting by seals of other species (mostly Harbor Seals, *Phoca vitulina*) is frequent. Northeastern Beach Tiger Beetles (*Cicindela d. dorsalis*) inhabit the upper beach as burrowing larvae and breeding adults. Invertebrate specialists are numerous and include several species of beetles, beach flies, and amphipods; on the south side of Cape Cod, ghost crabs (*Ocypode quadrata*) reach their northern limit of distribution.

Bank Swallows (*Riparia riparia*) nest in the top parts of the cliffs. Migrating Peregrine Falcons (*Falco peregrinus*) regularly perch on and hunt from the upper part of sea cliffs during the fall migration. Tiger beetles are characteristic animals of the base of sea cliffs.

A variety of seabirds, shorebirds, and songbirds nest on the dunes and in the interdunal area. Dunes are also extremely important to migratory birds, for food and cover during their

migrations. Diamondback Terrapins (*Malaclemys terrapin*) use dunes for nesting. Rare moths inhabiting the dunes include the Dune Noctuid Moth (*Oncocnemis riparia*) and the Straight-lined Mallow Moth (*Bagisara rectifascia*). Northeastern Beach Tiger Beetles (*Cicindela d. dorsalis*) overwinter in the dunes.

Small coastal islands can support all of these sandy natural communities, as well as many other habitats, but they are most important as refuges from mammalian and avian predators for colonial-nesting waterbirds, such as Leach's Storm-Petrel, Snowy Egret, Laughing Gull, Black-crowned Night-Heron, Common Eider, terns, and resident shorebirds.

Threats to Coastal Dunes, Beaches, and Small Islands

This sandy habitat is constantly changing, due to the strong effects of wind, wave action, and salt spray. However, they are also resilient in their natural state. Human uses of these areas are the greatest threat, because people try to stop the coast from changing, especially through beach stabilization efforts and interference with natural stabilizing mechanisms such as beach grass establishment colonization. Stabilization of cliffs deprives downstream beaches of their sediment supply and jetties and groins interrupt longshore drift of sediments. Trails, roads, and walkways exacerbate erosion can create cuts by creating channels through the dunes where winds and waves can follow, cutting through the dunes and overwashing interdunal areas with salt water. Vehicular traffic is directly harmful to stabilizing dune structure and vegetation, as well as disturbing or crushing nesting shorebirds and wildlife. Natural processes of erosion and accretion of sand in these habitats are important for maintaining suitable habitat for beach-nesting birds, including Piping Plover, Least Tern, and American Oystercatcher. Wild and domestic animals destroy or disturb nests, as well, causing abandonment of eggs or nestlings, in addition to eating eggs, nestlings, and fledglings. Oil spills and other pollutants are a major threat to coastal systems.

Proposed Conservation Actions

Proposed actions aimed at conserving rare and uncommon species of coastal dunes, beaches, and small islands in the future include, assuming adequate funding:

- Determining Species Habitat Polygons for each current occurrence of a state-listed animal of coastal dunes, beaches, and small islands, for use in prioritizing land protection, regulation, and research activities;
- Surveying for Beach Vole to determine its range, abundance, and distribution in the state, as this species is undersurveyed in Massachusetts, as well as funding research into the taxonomic status of this species;
- Surveying coastal heron rookeries on a regular basis;
- Surveying migrating shorebirds on a regular basis, and determining site usage and threats to the shorebirds;
- Monitoring trends in coastal waterbird populations;
- Limiting structural changes to dune systems, including building trails or walkways, roads, and bank stabilization;
- Restoring native vegetation where eliminated by human impacts and allowing natural processes of erosion and deposition to occur;
- Protecting land in and around coastal dunes, beaches, and small islands supporting populations of rare and uncommon animals;

- Prohibiting, regulating, and/or limiting off-road vehicles on coastal dunes, beaches, and small islands used by state-listed animals;
- Regulating and limiting the impacts of development and human use on coastal dunes, beaches, and small islands used by state-listed animals; and
- Researching the natural history of animals of coastal dunes, beaches, and small islands.

Monitoring Conservation Action Effectiveness

The effectiveness of these proposed conservation actions will be monitored by assessing the:

- Number and percentage of the Species Habitat Polygon delineations used in regulatory reviews and land protection planning;
- Number of research projects completed, on life histories of animals inhabiting coastal dunes, beaches, and small islands;
- Number of surveys completed for undersurveyed animals of coastal dunes, beaches, and small islands;
- Acres of land protected in and around coastal dunes, beaches, and small islands supporting rare and uncommon animals;
- Number of proposed alterations of coastal dunes, beaches, and small islands reviewed and regulated by DFW each year; and
- Number of conservation actions modified and adapted, using the results of monitoring.

References

Massachusetts Natural Heritage & Endangered Species Program. Various dates. Fact sheets on state-protected rare plants and animals, and on selected natural communities. Westborough, Massachusetts.

Swain, P.C., and J.B. Kearsley. 2000. *Classification of the Natural Communities of Massachusetts*. Draft. Massachusetts Natural Heritage & Endangered Species Program, Westborough, Massachusetts.

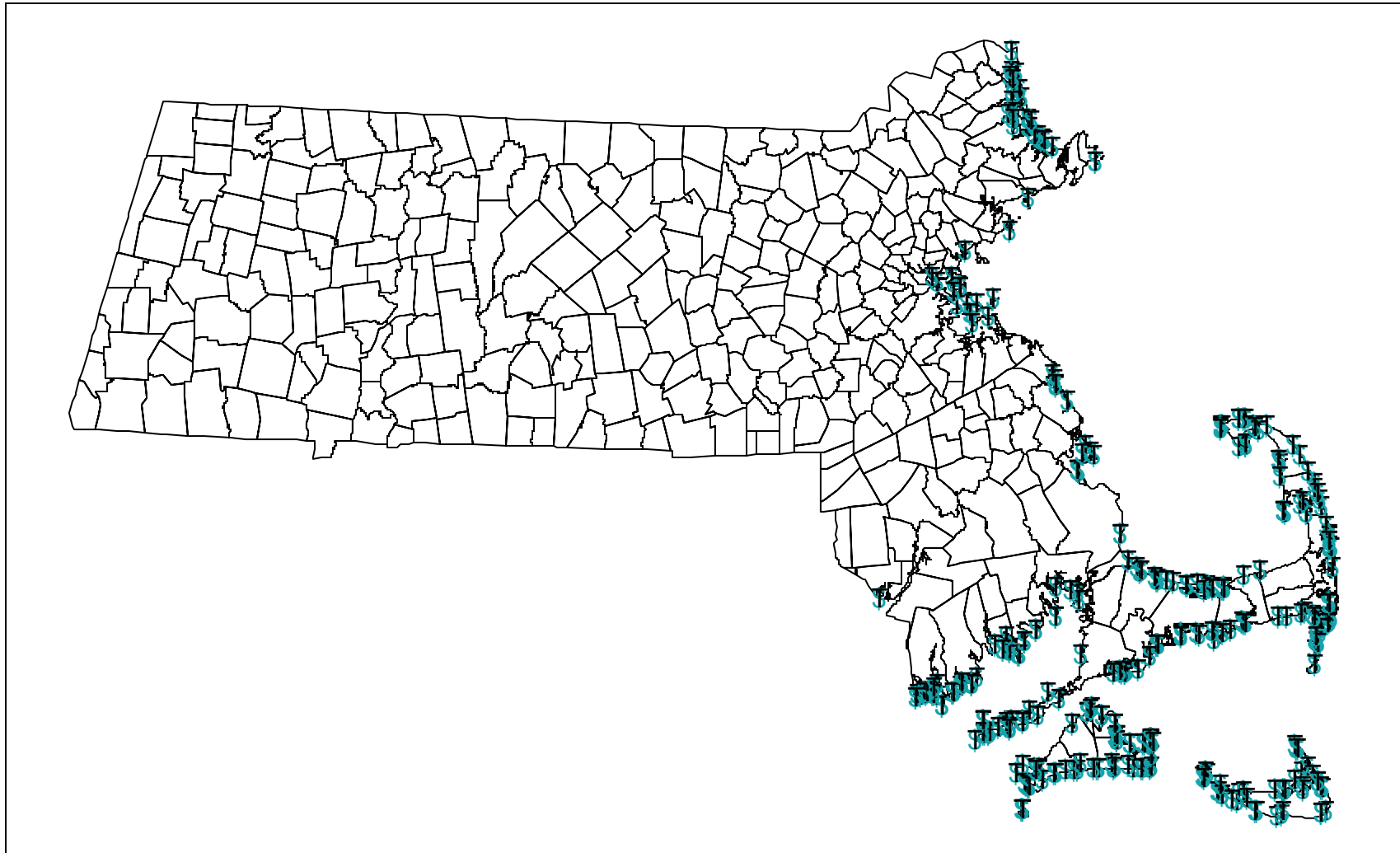


Figure 31: Coastal Dunes, Beaches, and Small Islands in Massachusetts.

7. Grasslands

Habitat Description

Disturbance-dependent habitats dominated by grasses are almost entirely anthropogenic communities and exist as a wide variety of types in Massachusetts.

Active pastures

Active pastures have usually been planted with non-native, cool-season forage grasses and are maintained by grazing livestock or mowing. They have value as habitat for a limited number of target species.

Airports and military bases

A few large grasslands located on airports and military bases in the state support grassland-dependent birds, such as Upland Sandpiper and Grasshopper Sparrow, and serve as important habitats for grassland dependent insects. These are the only mainland sites in Massachusetts large enough to support area-sensitive grassland birds.

Abandoned pastures

Abandoned pastures are extremely ephemeral and show a rapid increase in woody vegetation. These serve as habitat for a succession of animal communities that parallels the sere of the vegetation communities. In early stages, they are ideal nesting habitat for woodcock. As they become increasingly forested, they lose the capacity to support all but the most common species.

Native upland grasslands

Native grasslands dominated by little bluestem (*Schizachyrium scoparium*) occur throughout the state in various sizes and configurations. Early descriptions abound with references to open areas that probably were composed of numerous shrub and tree resprouts, with frequent grasses, forbs and ericads. The best and largest extant examples occur on Martha's Vineyard and Nantucket on lands that were plowed and grazed for decades. The effects of tropical storms, salt spray, coastal winds delayed their succession to shrubland, woodland and forest. A large proportion of protected species and other target species thrive in these habitats.

Savannahs

Based on historical evidence from pollen and charcoal studies and research on modern fire effects, homogeneous native grasslands would not likely have resulted simply from repeated fires. A structurally and compositionally complex landscape of fire-influenced habitats would also be conducive to the occurrence of oak woodlands savannas. These habitats would be neither grassland nor forest, but a mixture of both with canopy closure of <60%. This habitat type is currently nearly nonexistent on the Massachusetts landscape. Based on historical Native American settlement patterns and land use practices, savanna habitats would have occurred in every county in the state prior to European settlement. Savannahs are important to several Lepidoptera and birds targeted in this plan.

Wet meadows

Wet meadows occur in numerous situations, resulting from agricultural practices or controlled by hydrological dynamics. These are important for numerous target species including Spotted Turtle, Southern Bog Lemming, and Sedge Wren.

Species of Greatest Conservation Need in Grasslands

State Listing Status	Taxon Grouping	Scientific Name	Common Name	State Status
State-listed	Birds	<i>Circus cyaneus</i>	Northern Harrier	T
		<i>Bartramia longicauda</i>	Upland Sandpiper	E
		<i>Tyto alba</i>	Barn Owl	SC
		<i>Asio flammeus</i>	Short-Eared Owl	E
		<i>Poocetes gramineus</i>	Vesper Sparrow	T
		<i>Ammodramus savannarum</i>	Grasshopper Sparrow	T
		<i>Ammodramus henslowii</i>	Henslow's Sparrow	E
	Mammals	<i>Synaptomys cooperi</i>	Southern Bog Lemming	SC
	Beetles	<i>Cicindela purpurea</i>	Purple Tiger Beetle	SC
		<i>Nicrophorus americanus</i>	American Burying Beetle	E
	Lepidoptera	<i>Abagrotis nefascia</i>	Coastal Heathland Cutworm	SC
		<i>Callophrys irus</i>	Frosted Elfin	SC
		<i>Cynia inopinatus</i>	Unexpected Cynia	T
		<i>Digrammia eremiata</i>	Three-lined Angle Moth	T
		<i>Erynnis persius persius</i>	Persius Duskywing	E
		<i>Euchlaena madusaria</i>	Sandplain Euchlaena	SC
		<i>Faronta rubripennis</i>	The Pink Streak	T
		<i>Grammia phyllira</i>	Phyllira Tiger Moth	E
		<i>Ptichodis bistrigata</i>	Southern Ptichodis	T
Not Listed	Reptiles	<i>Heterodon platirhinus</i>	Eastern Hognose Snake	--
	Birds	<i>Colinus virginianus</i>	Northern Bobwhite	--
		<i>Falco sparverius</i>	American Kestrel	--
		<i>Scolopax minor</i>	American Woodcock	--
		<i>Sturnella magna</i>	Eastern Meadowlark	--

Seven species of state-listed birds in Massachusetts are highly dependent on grasslands of one type or another for nesting, migrations, or wintering habitat. Most of the nesting sites for these sites are clustered near the coast of the mainland or on the larger islands, but Vesper and Grasshopper Sparrows are also found in scattered locations, mostly airports, across the state. Four other birds, uncommon and declining in the state, are also associated with grassland habitats, although Northern Bobwhite, American Kestrel, and American Woodcock need less open kinds of grasslands than do Eastern Meadowlarks.

Southern Bog Lemmings tend to use wetter grasslands, while Eastern Hognose Snakes prefer drier, upland open areas, but the specific habitat preferences for both of these vertebrates are not at all well understood in Massachusetts.

In Massachusetts, American Burying Beetles are currently restricted to Martha's Vineyard and Nantucket, on both islands as a result of restoration efforts. Occurrences of Purple Tiger Beetles are also most common on the islands, but there are a few scattered sites for this beetle on the mainland, mostly in southeastern Massachusetts.

Nine state-listed rare moths and butterflies are associated with grassland habitats in Massachusetts. Sandplain grasslands, a type of native upland grassland, are the preferred habitat for many of these lepidoptera. These native grasslands are also highly threatened by development and fire suppression. Other types of grasslands used by these rare moths and butterflies include barrens within Pitch Pine/Scrub Oak communities, coastal heathlands and dunes, and dry, open oak woodlands.

Threats to Grasslands

The primary threats to grasslands are:

- Conversion to non-native grass species;
- Development;
- Succession, particularly as a result of fire suppression; and
- Invasive exotic species.

Proposed Conservation Actions

Proposed actions aimed at conserving rare and uncommon grassland species in the future include, assuming adequate funding:

- Determining Species Habitat Polygons for each current occurrence of a state-listed grassland animal;
- Surveying for Southern Bog Lemming and grassland lepidoptera to determine their range, abundance, and distribution in the state, as these species are undersurveyed in Massachusetts;
- Protecting and managing land in and around grasslands supporting populations of rare and uncommon animals;
- Converting protected grasslands currently dominated by non-native cool season grasses and other exotic invasive plant species to grasslands dominated by native grasses, forbs and ericads;
- Developing management agreements with airports and military bases that promote conservation of grassland animals;
- Regulating and limiting the impacts of development on grasslands used by state-listed animals; and
- Researching the natural history of grassland animals.

Monitoring Conservation Action Effectiveness

The effectiveness of these proposed conservation actions will be monitored by assessing the:

- Number and percentage of the Species Habitat Polygon delineations used in regulatory reviews and land protection planning;
- Number of research projects completed, on grassland animal life histories;
- Number of surveys completed, for undersurveyed grassland animals;
- Acres of nonnative grassland converted to native grassland;
- Number of management agreements completed with airport and military base operators;
- Acreage of managed grasslands on protected land;
- Acres of grasslands protected, supporting rare and uncommon animals;

- Number of proposed grassland alterations reviewed and regulated by DFW each year; and
- Number of conservation actions modified and adapted, using the results of monitoring.

References

Vickery, P.D., and P.W. Dunwiddie 1997. *Grasslands of Northeastern North America: Ecology and Conservation of Native and Agricultural Landscapes*. Massachusetts Audubon Society, Lincoln, Massachusetts.

8. Young Forests and Shrublands

Habitat Description

Collectively, young forests and shrublands are referred to as “thicket” habitats (Litvaitis 2003), and provide important resources for several wildlife species of conservation concern. Young forest habitats are typically dominated by rapidly growing trees and shrubs, and generally occur when a mature forest canopy is disrupted, allowing sunlight to stimulate the growth of herbaceous and woody vegetation on the forest floor. Shrublands are defined here as relatively ephemeral, upland habitats that are dominated by low woody vegetation (generally <3 m tall), with varying amounts of herbaceous vegetation and sparse tree cover. Shrublands primarily include abandoned field sites and power line corridors that would ultimately revert to forest absent some human or natural disturbance (e.g., mowing or burning), and abandoned beaver flowages along forested stream courses, which typically succeed from wet meadow to drier herb/shrub habitat, and eventually revert to forest in the decades following abandonment.

Enduring shrubland habitats also occur, and include both pitch pine-scrub oak communities on relatively dry upland sites, as well as shrub-dominated wetland communities (generally referred to as “shrub swamps”). These enduring shrublands provide unique habitats and support particular wildlife species of conservation concern, and so are treated separately in this report.

While several wildlife species use both young forest and shrubland (Litvaitis 2003), there are important differences in plant species composition and structure (Lorimer 2001) that result in some species of plants (Latham 2003) and animals (Wagner et al. 2003) occurring in one or the other. The woody vegetation in young forest is often dominated by regenerating stands of late successional species that are present as advanced reproduction or seed at the time of a canopy disturbance. Shrublands tend to be dominated by pioneer species whose seed can travel substantial distances (Lorimer 2001). The distinction between young forest habitat dominated by late-successional species and shrublands dominated by pioneer species has received little attention from researchers, but may prove to be a key consideration in regional conservation planning (Askins 2001). Absent disturbance, the thicket habitats discussed here eventually succeed to mature forest.

Preserving biodiversity in temperate forest requires the maintenance of all successional stages (Franklin 1988), and managers should recognize the role of disturbance in maintaining biodiversity (DeGraaf and Miller 1996). Forest managers need to provide a range of habitats at temporal and spatial scales that will support viable populations of all native wildlife species, and this task must be accomplished in a landscape being developed for human use that does not resemble any previous historical condition. While it is instructive to examine the historical range of variability associated with natural disturbance regimes (see Thompson and DeGraaf 2001), managers should not seek to re-establish conditions from a previous time (e.g., prior to European settlement), but rather should seek to secure a range of conditions in today’s landscape that will support viable populations of native wildlife species (DeGraaf and Yamasaki 2003).

Young Forests

Young forest constitutes the first of four developmental stages of forest growth, and is technically referred to as “stand initiation” (Oliver and Larson 1996). The stand initiation stage is characterized by high stem densities (e.g., 1,000 to >10,000 stems per acre) and is relatively

ephemeral, generally lasting about 10 years or until a young tree canopy is formed, typically causing herbaceous and woody vegetation on the forest floor to die back. The competition for sunlight within a young forest canopy typically results in a rapid decline in stem density during the stem exclusion stage. Canopy gaps form as the result of stem exclusion, which facilitates plant growth on the forest floor during the understory re-initiation stage. Over time, an uneven-aged forest is formed and stands eventually enter the old growth stage (Oliver and Larson 1996).

During the stand initiation stage, the flush of woody and herbaceous vegetation on the forest floor provides food (e.g., berries, browse, and insects) and cover (e.g., shrubs, tree seedlings, and slash) resources for wildlife that is generally lacking in older forest. Wildlife species that prefer early successional habitats have been perceived as habitat generalists (see Foster and Motzkin 2003), but in fact, many wildlife species associated with young forests are habitat specialists with specific vegetation structure or area requirements, such as the New England Cottontail and Chestnut-sided Warbler (DeGraaf and Yamasaki 2003). Relatively large (>25 acre) patches of early successional habitat may be necessary to maintain viable populations of mammals associated with young forest (Litvaitis 2001).

In addition, Hunter et al. (2001) note that early successional habitats are important for wildlife species generally associated with mature forests. Examples include fledgling and molting adult Wood Thrushes (*Hylocichla mustelina*) that move from mature forest to patches of disturbed habitat that may be critical for food and cover resources not typically found near nesting sites.

Young forest established by clearcutting can temporarily reduce amphibian numbers (Pough et al. 1987), including the terrestrial-breeding Redback Salamander (*Plethodon cinereus*) (DeGraaf and Yamasaki 1992 and 2002), the wetland-breeding Wood Frog (*Rana sylvatica*), and mole salamanders (*Ambystoma* spp.) (deMaynadier and Hunter 1998), which require a moist environment and are not especially mobile. However, a shaded canopy is usually restored within 10 years, Redback Salamander numbers typically recover to pre-cut levels within 30 years (DeGraaf and Yamasaki 2002), and there is generally no difference in numbers of salamanders in 60-year-old second-growth forest vs. old-growth forest (Pough et al. 1987). Maintaining sustainable populations of amphibians can be compatible with timber harvesting (deMaynadier and Hunter 1995, Brooks 1999).

Generally, a minority of forest area is in an early successional stage at any given point in time, so the many habitat benefits of young forest can be realized without any substantial threat to populations of mature forest species. Overall, young forests support a great diversity of wildlife species and are a critical component of wildlife habitat at the landscape level (DeGraaf and Yamasaki 2001, 2003).

Mature forest canopies in New England have historically been disrupted by various natural disturbance events, including wind (e.g., down-bursts, tornadoes, or hurricanes), fire (e.g., lightning strikes and intentional spring fires set by native Americans), flooding (e.g., beaver impoundments and spring floods along major rivers and streams), and pathogens (e.g., insect infestations) (see DeGraaf and Miller 1996, pp. 6-10 for review). Wind disturbances have occurred historically throughout Massachusetts, with hurricanes being more prominent in eastern Massachusetts, and down-bursts and tornadoes more prevalent in western Massachusetts. Fire

was historically more common in the eastern part of the state and in the major river valleys. Beaver flooding occurred throughout the state until beaver were extirpated from nearly all of Massachusetts by 1700 (Foster et. al. 2002) (limited beaver flooding occurs today in all but the southeastern part of the state since beaver were re-established during the 20th century). Pathogens most likely had sporadic historical impact throughout the state.

Historical return intervals for canopy-replacing wind and fire disturbance events vary across Massachusetts, and are generally highest in the pitch pine-oak barrens of coastal and eastern Massachusetts (40-150 years between severe fires and/or hurricanes), followed by oak-hickory forests (85-380 years between fires and/or wind events), northern hardwood forest (500-1,500 years between wind events and occasional fires), and spruce-northern hardwood forest (230-545 years between wind, insect, and/or fire events) (Lorimer and White 2003). These disturbance intervals indicate that 10-31% of pitch pine-oak barrens naturally occur in early successional (≤ 15 year-old) forest, compared to 3-40% of oak forests, 1-3% of northern hardwood forests, and 2-7% of spruce-northern hardwood forest (Lorimer and White 2003).

Patch sizes for individual wind and fire disturbances appear to range between <1 acre to a few thousand acres, with the majority of individual disturbance patches being toward the small end of the range. For example, it has been estimated that the majority of natural disturbance patches in original northeastern forest caused by wind, water, or pathogens commonly occurred in gaps <0.05 ac (Runkle 1982). However, while the great majority of disturbance patches are relatively small, the few large disturbance patches that do occur account for a substantial amount of all young forest (e.g., $>40\%$ of total blowdown patch area in northern hardwood forest) and likely provide important habitat for early successional wildlife species that are area-sensitive (Lorimer and White 2003).

Larger patch sizes tend to be associated with more frequent disturbance intervals, but a range of patch sizes occur across all four of the general forest types discussed here. Historically, the largest individual wind and fire disturbance patch sizes appear to range from about 700 ha in northern hardwood forest to more than 1,000 ha in pitch pine-oak barrens in the northeast (Lorimer and White 2003). Disturbance patterns are spatially non-random, and are highly influenced by soil and topographic features and human settlement patterns (Lorimer 2001). Natural disturbances often overlap and as a result some trees never fully mature before a subsequent disturbance destroys them, while other trees can attain old-growth status if they escape natural disturbance over two or more centuries.

Young forests were extremely common in Massachusetts during the late nineteenth and early twentieth century as abandoned farmland reverted to forest cover (Figure 32). Today, however, only 5% of forestland in the state occurs in an early successional (seedling/sapling) condition (Alerich 2000) (Figure 32). Early successional habitats are currently less common in southern New England than they were in pre-settlement times (Litvaitis 1993, DeGraaf and Miller 1996). Wind events still provide some young forest in Massachusetts today, but the impact of fire and beaver flooding on the landscape has been curtailed as a result of European settlement and subsequent development (Askins 2001).

Fire has largely been excluded from the Massachusetts landscape. Residential developments are now dispersed throughout the pitch pine-oak barrens and oak forests of eastern Massachusetts where fire historically provided early successional habitat. It is more difficult to appreciate the loss of early successional habitat that resulted from beaver flooding because beaver are active on the Massachusetts landscape today, and continually cause problems for people by plugging road culverts and temporarily flooding well and leach fields in residential areas.

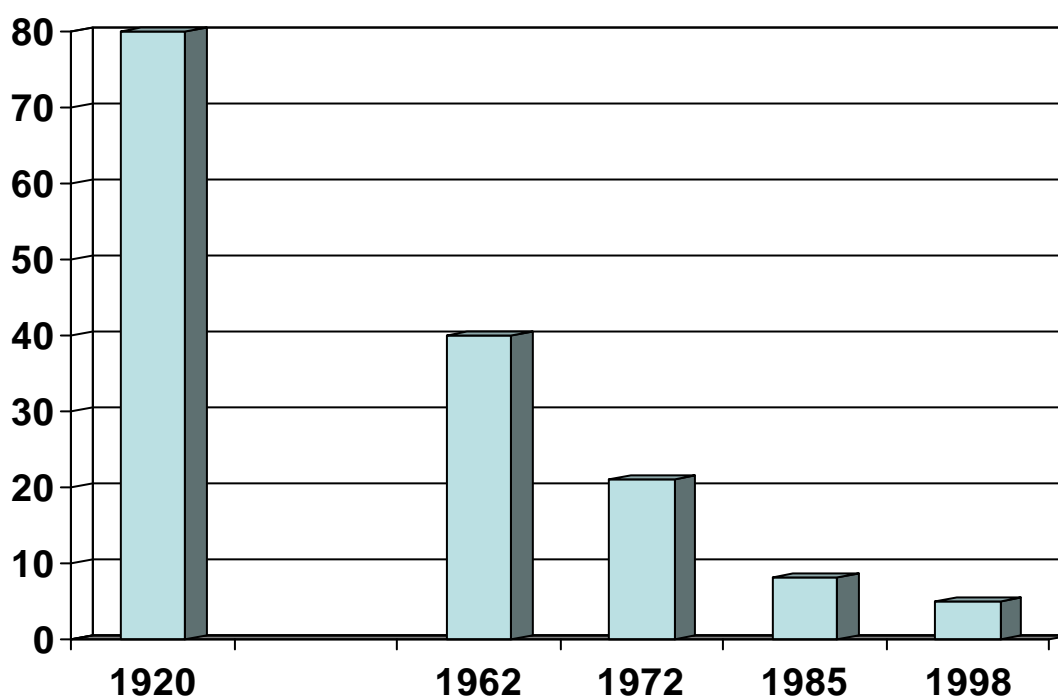


Figure 32: Percent early successional (seedling/sapling) forest in Massachusetts (U.S. Forest Service data).

Given current problems caused by beaver activity, it is difficult to appreciate that beaver flowages likely occupied far greater areas of what is now Massachusetts during pre-settlement times. Beaver activity historically occurred most frequently on lower slopes and along low-gradient streams in Massachusetts (Howard and Larson 1985). These low-lying sites have generally been the focus of human development in Massachusetts, and therefore no longer support extensive beaver activity.

We simply do not know the extent of these historic beaver-influenced habitats. However, we do know that the Massachusetts Bay Colony in what is now southeastern Massachusetts reported shipments of over six tons of beaver pelts to Britain in the 1620's (Foster et al. 2002). While these shipments likely included some pelts trapped from inland areas, it is still sobering to consider that few or no beaver occur today in many portions of southeastern Massachusetts. Likewise, we know that during the five-year period from 1652 to 1657, fur trader John Pynchon shipped 8,992 beaver pelts from Springfield, Massachusetts in the Connecticut River drainage (Judd 1857 in DeGraaf and Miller 1996). In contrast, approximately 6,500 beaver pelts were

tagged by all licensed trappers in the entire state of Massachusetts during the five-year periods from 1985-1990 and 1990-1995 (MassWildlife unpublished data). In pre-colonial New York state, beaver-created floodplains occurred on about one million acres, or 3.5% of the state. The extent of these floodplains is now reduced by 65% (Gotie and Jenks 1982 in Hunter et al. 2001).

Historically, as dams were abandoned after beaver food resources (primarily tree bark and twigs) became depleted, the impoundments slowly drained, and succeeded first to wet meadow, and then to shrubland and young forest as former impoundments dried more completely. After adequate woody growth become re-established, beaver typically re-occupied these low-lying sites, built new dams, and began the dynamic process of habitat modification all over again. Because human development in Massachusetts is concentrated in low-lying areas along rivers and streams where beaver activity is largely excluded, an important source of young forest habitat formerly associated with these sites has been substantially diminished.

Shrublands

Common upland shrubs within ephemeral shrublands in the northeastern United States include blackberry and raspberry (*Rubus* spp.), and blueberry (*Vaccinium* spp.) (Latham 2003, Wagner et al. 2003). Rare species associated with shrublands in the northeastern U.S. tend to occur in enduring shrub habitats as opposed to ephemeral shrub habitats (Latham 2003), and this may be especially true for Lepidoptera (Wagner et al. 2003). Recent work in Massachusetts indicates that shrublands along power line corridors and at reclaimed abandoned field sites support a diverse assemblage of Lepidoptera, but do not typically support rare species of butterflies and moths (King and Collins 2005). Overall, shrublands are the most important natural community type for rare and endangered Lepidoptera in Massachusetts (Wagner et al. 2003).

Species of Greatest Conservation Need in Young Forests and Shrublands

State Listing Status	Taxon Grouping	Scientific Name	Common Name	State Status
State-listed	Reptiles	<i>Elaphe obsoleta</i>	Eastern Ratsnake	E
	Birds	<i>Vermivora chrysoptera</i>	Golden-Winged Warbler	E
		<i>Oporornis philadelphia</i>	Mourning Warbler	SC
	Mammals	<i>Synaptomys cooperi</i>	Southern Bog Lemming	SC
Not Listed	Reptiles	<i>Coluber constrictor</i>	Black Racer	--
		<i>Heterodon platirhinos</i>	Eastern Hognose Snake	--
	Birds	<i>Bonasa umbellus</i>	Ruffed Grouse	--
		<i>Buteo platypterus</i>	Broad-Winged Hawk	--
		<i>Caprimulgus vociferus</i>	Whip-poor-will	--
		<i>Colinus virginianus</i>	Northern Bobwhite	--
		<i>Dendroica discolor</i>	Prairie Warbler	--
		<i>Empidonax traillii</i>	Willow Flycatcher	--
		<i>Falco sparverius</i>	American Kestrel	--
		<i>Pipilo erythrophthalmus</i>	Eastern Towhee	--
		<i>Scolopax minor</i>	American Woodcock	--
		<i>Spizella pusilla</i>	Field Sparrow	--
		<i>Toxostoma rufum</i>	Brown Thrasher	--
		<i>Vermivora pinus</i>	Blue-winged Warbler	--
		<i>Zonotrichia albicollis</i>	White-throated Sparrow	--
	Mammals	<i>Sylvilagus transitionalis</i>	New England Cottontail	--
	Lepidoptera	<i>Hadena ectypa</i>	A Noctuid Moth	--

Among vertebrate wildlife species in New England, 13% (3 of 13) of amphibians, 62% (16 of 26) of reptiles, 37% (79 of 214) of birds, and 72% (46 of 64) of mammals utilize shrub/old field habitats (DeGraff and Yamasaki 2001). Some vertebrate species demonstrate preferred use of shrub/old field sites, including reptiles like the Eastern Ratsnake, Eastern Hognose Snake, and Spotted Turtle, birds such as the Willow Flycatcher, Blue-winged Warbler, and Song Sparrow, and mammals like the New England Cottontail, white-footed mouse, and ermine (DeGraff and Yamasaki 2001). Lagomorphs can be considered obligate users of shrubland habitats, and species such as Bobcat that prey on lagomorphs will certainly use shrubland habitat, but may use other habitat types as well to secure alternative prey sources (Fuller and DeStefano 2003).

Threats to Young Forests

Development and forest cutting practices are likely the two biggest threats to young forest habitat. Despite the fact that Massachusetts was the only state in the nation in which the U.S. Census reported a decline in 2004 in its human population, development continues to convert forest and agricultural sites to residential and suburban developments. More than 157,000 acres of land were developed in Massachusetts between 1985 and 1999 (an annual average of about 11,200 acres/year), and virtually all of this land was previously forested habitat (Breunig 2003). Of the approximately 132 million board feet of timber cut annually in Massachusetts (Alerich 2000), only 45% (about 60 million board feet) can be accounted for from cutting that occurs on land that remains in forest use (Dept. of Conservation and Recreation 2005). The remaining 55% (about 72 million board feet) is apparently harvested from land as it is converted to non-forest use. This estimate can be verified using forest inventory analysis (FIA) data from the U.S. Forest Service, and land use data from the Massachusetts Audubon Society. With an average of about 6,300 board feet per acre of Massachusetts forestland (Alerich 2000), and an average of 11,200 acres of forestland developed annually throughout the state, approximately 71 million board feet of timber is generated annually from forested land converted to development.

Human activity, primarily forest cutting practices, can potentially offset some negative impacts on the creation of young forest habitat that result from loss of beaver floodlands, fire, and other natural disturbances. However, harvesting on land that remains in forest use tends to occur as partial cuts that remove about one-third of the standing volume, and thus do not produce young forest habitat. Of the average 6.3 mbf per acre standing in Massachusetts forestlands today (Alreich 2000), an average 2.1-2.2 mbf per acre is reportedly cut during timber sale operations (DCR 2005). Despite the fact that about 60 million board feet of timber are cut annually in Massachusetts from land that remains in forest use (DCR 2005), the availability of young forest habitat continues to decline (Figure 32).

Many private landowners report aesthetic concerns about even-aged cutting practices (especially clearcutting) that provide young forest habitat. In addition to aesthetic concerns, diverse landowner objectives, declining average size of land holdings, and frequent turnover of private forestlands present major challenges to managing forest habitats to benefit wildlife (Brooks and Birch 1988). As a result, the availability of young forest habitat continues to decline in Massachusetts.

Further, pre-settlement forests that formerly occupied what is now developed land likely experienced more frequent natural disturbance than other lands remaining in forest use today. Development following European settlement was focused in low-lying areas along rivers and streams because waterways provided the primary means of transporting goods, and because existing Native American clearings could be readily occupied by European settlers. Forests along waterways were formerly subjected not only to periodic wind, fire, and pathogen events that also impact forests at higher elevations, but also to repeated cycles of ice-scouring and spring flooding (along rivers), or beaver flooding and abandonment (along low-gradient streams). The disproportionate abundance of early successional habitats that likely occurred in forested sites that are now developed for human use must be replaced today in somewhat higher elevation forests, and even-aged silvicultural practices can provide ecologically and economically sustainable early successional habitats for wildlife.

Finally, beaver impacts on forests are reduced not only within developed portions of the landscape (e.g., within cities and towns), but also adjacent to infrastructure such as roads that support development. Beaver activity is understandably restricted by humans wherever a road crosses a stream, in order to avoid damage to the road. Beaver activity is typically constrained along a reach of stream above and below the road crossing, and the potential for beaver-generated young forest is correspondingly reduced, regardless of whether or not areas up-stream and down-stream of the crossing are developed.

Threats to Shrublands

Development of abandoned agricultural sites is probably the single biggest threat to ephemeral shrublands. More agricultural land was converted to development throughout Massachusetts between 1985 and 1999 than remains in agricultural use today; more than 500,000 acres of agricultural land was converted to development between 1985 and 1999 (Breunig 2003), and only about 314,000 acres remains in agricultural use today (MassGIS 2003). Only 6% (313,884 of 5,173,947 acres) of Massachusetts is active farmland at present, and only 3.3% (170,729 of 5,173,947 acres) of all lands in the state are classified as “open land”, which consists primarily of abandoned agricultural sites, power lines, and areas of no vegetation (MassGIS 2003).

Wagner et al. (2003) note that an overlooked threat to butterflies and moths (Lepidoptera) that occupy shrublands is overgrazing of larval host plants by dense populations of white-tailed deer. Deer population levels in eastern Massachusetts are generally above target levels, and are rising (Woytek, personal communication). Therefore, keeping shrublands open to public hunting and maintaining adequate hunting pressure to control deer numbers will likely benefit wildlife species of conservation concern in Massachusetts that occupy shrubland habitats.

Conservation Actions

While about 79% of forestland in Massachusetts is privately owned (Alerich 2000), the best opportunities in the near future for creating high-quality young forest habitat are likely to occur on public lands. Modified even-aged silvicultural practices that address both aesthetic concerns and habitat requirements have been applied on some state lands, and can serve as a model for private lands. Most state lands in Massachusetts, including state forest lands, state wildlife lands, and state watershed lands have been “Green Certified” to the Forest Stewardship Council (FSC) standard for sustainable forest management. Young forest habitat that results from silvicultural

practices on these state lands meets specific criteria for ecological, economic and social sustainability (Seymour et al. 2004).

In particular, landscape composition goals for state wildlife lands call for 15-20% young forest, as well as 10-15% late-successional forest. Young forest habitat is established on state wildlife lands using modified even-aged silvicultural practices. Aggregate retention cuts remove 75-85% of the overstory at one time, and retain 15-25% of the overstory in clusters of mature trees. Shelterwood retention cuts remove up to 90% of the overstory in two cuts over a period of 5-10 years, and retain at least 10% of the original overstory in both individual trees and clusters of trees. Retention of mature trees provides structural diversity as well as relatively cool, moist micro-sites. These attributes should reduce the amount of time needed for some wildlife species to re-occupy harvested sites compared to the time needed following traditional clearcutting practices. DFW may be able to encourage private forest landowners who report that wildlife habitat is an important objective to adopt these practices.

Some shrubland birds may be better suited to successfully exploit relatively small habitat patches (1-10 ha) within or adjacent to suburban landscapes than other wildlife species that require more extensive grassland or forest patches (Dettmers 2003). Therefore, successful wildlife conservation at a landscape scale may be facilitated by focusing forest conservation efforts in relatively un-fragmented parts of the state, and by conserving viable shrubland habitats even in developed parts of Massachusetts.

Finally, it is critical to maintain and manage ephemeral shrublands such as abandoned field sites through periodic mowing and/or burning, and through public and private non-profit land acquisition.

In addition to forest management actions, other proposed actions aimed at conserving young forest and shrubland animals in the future include, assuming adequate funding:

- Determining site-specific Species Habitat Polygons for each current occurrence of a state-listed young forest and shrubland animal, to inform land protection and regulatory priorities and actions;
- Intensive and continued surveying for young forest and shrubland birds, as these species are relatively easy to survey and can serve as indicators of the quality and stage of these habitats;
- Protecting young forests and shrublands supporting populations of rare and uncommon animals;
- Establishing, restoring, and managing these ephemeral habitats through methods other than forestry, such as prescribed fire and targeted removal of invasive plant species;
- Regulating and limiting the impacts of development on young forests and shrublands used by state-listed animals; and
- Educating/informing the public about the values of young forests and shrublands and the issues related to their conservation, through agency publications and other forms of public outreach, in order to instill public appreciation and understanding.

Monitoring Conservation Action Effectiveness

The effects of proposed conservation actions will be evaluated by monitoring the diversity and abundance of plant and animal species across a range of sites on state wildlife lands where even-aged silviculture is applied. Monitoring occurs both before and after forest cutting practices are carried out. While the majority of plant species (including both herbaceous and woody plants) can be monitored effectively, it is not feasible to monitor all animal species. In general, forest songbirds are used as a surrogate indicator of wildlife community response, although butterflies and moths, and/or salamanders can also provide good insight into the sustainability of even-aged forest cutting practices.

In addition, current monitoring efforts by DFW's Upland Habitat Management Program will continue. These including studies of songbird nesting success and Lepidoptera use of forest clearcuts, abandoned field sites, and powerline rights of way, conducted through a collaborative effort with the U.S. Forest Service Northeast Experiment Station and the Massachusetts Audubon Society.

The effectiveness of these proposed conservation actions will be monitored by assessing the:

- Number and percentage of the Species Habitat Polygon delineations used in regulatory reviews and land protection planning;
- Number of surveys completed for young forest and shrubland animals;
- Acreage of young forests and shrublands protected, through fee acquisition or conservation restriction, supporting rare and uncommon animals;
- Number of management efforts of all types, aimed at establishing, restoring, or continuing these ephemeral habitats, and acreage affected by these management efforts;
- Number of proposed alterations to young forests and shrublands reviewed and regulated by DFW each year;
- Number of conservation management permits (part of regulation of proposed developments) monitored, when those permits were issued by DFW for these species; and
- Number of conservation actions modified and adapted, using the results of monitoring.

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9. Riparian Forest

Habitat Description

Riparian forests occur in a linear form along streams or rivers, following the stream or river meanders. Their soils and moisture levels are influenced by the adjacent streams and rivers. Riparian forests include all the types of floodplain forests, alluvial forests, and streamside forests. Along the bigger rivers, such as the Connecticut, the floodplain is quite wide; narrower streams have narrower riparian zones. Floodplains are of variable width, sometimes with adjacent uplands occurring distinctly; in other places the changes are gradual, reflecting occasional flooding and flatter topography. In general, riparian forests are flooded in the spring and dry out during the growing season, although floods may occur at anytime.

Riparian zones vary with timing, magnitude and duration of flooding, flow rate, and the types of sediments carried and dropped by the floodwaters. These transition areas connect rivers to uplands and they provide distinct habitats in themselves. They protect the uplands from the river in flood, and protect the river by slowing runoff and absorbing inputs from the uplands.

Species of Greatest Conservation Need in Riparian Forest

State Listing Status	Taxon Grouping	Scientific Name	Common Name	State Status
State-listed	Amphibians	<i>Gyrinophilus porphyriticus</i>	Spring Salamander	SC
	Reptiles	<i>Clemmys insculpta</i>	Wood Turtle	SC
	Birds	<i>Parula americana</i>	Northern Parula	T
	Odonates	<i>Boyeria grafiana</i>	Ocellated Darner	SC
		<i>Gomphus abbreviatus</i>	Spine-Crowned Clubtail	E
		<i>Gomphus desertus</i>	Harpoon Clubtail	E
		<i>Gomphus fraternus</i>	Midland Clubtail	E
		<i>Gomphus quadricolor</i>	Rapids Clubtail	T
		<i>Gomphus vastus</i>	Cobra Clubtail	SC
		<i>Gomphus ventricosus</i>	Skillet Clubtail	SC
		<i>Neurocordulia obsoleta</i>	Umber Shadowdragon	SC
		<i>Neurocordulia yamaskanensis</i>	Stygian Shadowdragon	SC
		<i>Ophiogomphus aspersus</i>	Brook Snaketail	SC
		<i>Ophiogomphus carolus</i>	Riffle Snaketail	T
		<i>Somatochlora elongata</i>	Ski-Tailed Emerald	SC
		<i>Somatochlora forcipata</i>	Forcinate Emerald	SC
		<i>Somatochlora georgiana</i>	Coppery Emerald	E
		<i>Somatochlora kennedyi</i>	Kennedy's Emerald	E
		<i>Somatochlora linearis</i>	Mocha Emerald	SC
		<i>Stylurus amnicola</i>	Riverine Clubtail	E
		<i>Stylurus scudderii</i>	Zebra Clubtail	E
		<i>Stylurus spiniceps</i>	Arrow Clubtail	T
	Lepidoptera	<i>Papaipema</i> sp. 2	Ostrich Fern Borer	SC
Not Listed	Birds	<i>Butorides virescens</i>	Green Heron	--
		<i>Seiurus motacilla</i>	Louisiana Waterthrush	--
		<i>Wilsonia canadensis</i>	Canada Warbler	--
	Lepidoptera	<i>Hadena ectypa</i>	A Noctuid Moth	--

Riparian forests differ from other forested wetlands in their patterns of flooding (seasonality and duration); in receiving large pulses of energy and nutrients from upstream, and in having organic material deposited and removed. The riparian area provides productive and diverse habitats. Beside the open water, sunlight reaches into the forest, often supporting denser shrubs, vines and herbaceous plants – good cover for wildlife. More diverse habitats come from the different vegetation supported by local topography such as low and high areas within the riparian zone. The riparian forest provides valuable habitat for many animals, with the proximity to streams and river, open water, diversity of vegetation, linearity, and connections up and downstream via the river corridor. Species density is often higher in riparian forests than in other forest types (Mitsch & Gosselink, 2000). Riparian forests are often the only forests in built up areas, and provide refuge to many species in those cases. Forested wetlands along streams and rivers can be corridors for travel through otherwise unsuitable (developed) habitat – including for moose, deer, and other large mammals.

Riparian forests are insect-rich habitats that attract warblers, thrushes and other songbirds. In particular, Yellow-throated and Warbling Vireos, which like to nest in the canopies of riverside trees, are frequently observed in riparian forest communities. Raptors such as Bald Eagles and Red-shouldered Hawks also use riverbank trees as perch sites. In spring floods, Wood Ducks and Hooded Mergansers like the shady edges of riparian forests and the interior meander scar pools. Eastern Comma butterflies feed on elm and nettles. A large number of dragonfly and damselfly species, including many state-listed species, spend one to several years as larvae in the streams and rivers, and emerge to take refuge in the floodplain forest as their exoskeletons harden and they mature. Odonates also use riparian forests for roosting during inclement weather, or, in the case of crepuscular species, until twilight feeding times. Sexually mature adults typically return to patrol river and stream banks, feeding, mating, and laying eggs. Interior meander scars and sloughs function as vernal pools, providing breeding habitat for many frog species, such as Leopard and Pickerel frogs, American Toads, and mole salamanders, such as the state-listed Blue-spotted Salamander. Riparian forests also provide sheltered, riverside corridors for dispersing mammals and migratory songbirds, as well as residents that may breed or feed in them.

Fish, reptiles and amphibians particularly need the co-occurrence of open water and forest that makes riparian forests attractive habitat to many animal species. Many fish species rely on the food, spawning and rearing habitat provided by floodplain forests. Floodplain forests also slow water velocities, reducing erosion and providing locations for deposition of fine sediments, that might otherwise clog spawning substrates within the river channel. Perhaps most importantly for fish, floodplain forests provide allochthonous inputs (leaves, detritus, and other nutrients), stability (to prevent excessive erosion), and shade moderate thermal regimes. Wood Turtles are most strongly associated with flowing water (streams and rivers) and adjacent early successional uplands (Fowle, 2001) used for feeding, aestivating, nesting, and thermoregulation. Spotted Turtles and Blanding's Turtles also use riparian forests regularly, as well as other wetlands. Along smaller streams, sphagnum hummocks over moving water provide important nesting habitat for Four-toed Salamanders. Spring Salamander habitat includes clear, well-oxygenated, and often high-gradient streams, which are located within riparian forests primarily found in the northwestern part of the state. Occasionally this species can be found on land within the riparian forest, traveling between streams, but its common location is hidden under cover along the

stream bottom. One of the habitats of the more common Eastern Hognosed Snake is riparian forest.

Numerous forest communities occur in riparian zones, providing a variety of habitats including a rich variant of red maple swamp that occurs in low areas along rivers and streams that experience overbank flooding. Alluvial Atlantic white cedar swamps also provide a richer mix of species than do non-riparian occurrences, but still retain some of the species that are primarily associated with Atlantic white cedar. Northern Parula warblers and Hessel's Hairstreak butterflies are examples. Other areas have hemlock, mixed with the cedars or deciduous species, or occurring alone in the canopy, further providing a mix of habitats for wildlife. Backwater areas of floodplain forest often have large quantities of ostrich fern, which support the state-rare Ostrich Fern Borer Moth.

Threats to Riparian Forests

Threats to riparian forests include alteration of natural hydrology through damming or other changes in the natural river flow and flood patterns, including water withdrawal and straightening streams. The more than 3,000 dams statewide have created an alternating problem of accelerated floodplain development within the impoundment, and floodplain starvation between impoundments. This results in impoundments that fill with sediments, nutrients, and often contaminants. Reaches between dams become incised. As the sediment-starved channel digs deeper into the local geology, higher flood flows are needed to connect the river to the surrounding floodplain. Once the recurrence of flooding in an area drops, the temptation becomes to encourage development on these floodplains which further exacerbates the issues associated with floodplain encroachment, as well as the cost associated with flood damage. Maintenance of natural flooding intensity and patterns is needed to maintain the vegetation and habitats in the riparian zones. Just as impounding stretches of stream causes disruption to the natural flow regime, tiling or draining riparian forests would also cause the forest and stream habitats to change drastically. Stream habitats downstream would be impacted by accelerated draining and increases in damaging flood flows.

In a 1997 statewide floodplain forest community inventory (Kearsley 1999), non-native plant species were observed at all floodplain forest sites surveyed, but they appeared to be localized to areas where the canopy was opened, the herbaceous layer was cleared, and the soil was disturbed. Non-native invasive species cause great changes in habitat by altering the structure of the shrub and herbaceous layers, and by competing with tree seedlings which ultimately changes the canopies. For example, Japanese knotweed (*Polygonum cuspidatum*) currently poses a great threat to riparian forests because of its ability to spread rapidly and shade out all other herbaceous plants. There are no truly effective ways to eradicate Japanese knotweed once it has established. The best way to avoid its spread is to prevent its establishment by avoiding all clearing and disturbance within riparian forest areas, particularly on the sandier banks. Many other invasive species are found in riparian areas, changing the species and structural composition of the forests, and changing the habitats available to native wildlife.

Proposed Conservation Actions

Proposed actions aimed at conserving rare and uncommon riparian forest species in the future include, assuming adequate funding:

- Determining Species Habitat Polygons for each current occurrence of a state-listed riparian forest animal;
- Expanding ongoing inventories of rare dragonfly and damselfly species to expand baseline information and to further refine their ranges, abundances, and distribution in the state, as the species are generally undersurveyed in Massachusetts, as well as determining areas of use by adult dragonflies (how far into the forest do they typically go; what forest characteristics do they prefer);
- Protecting riparian forests supporting populations of rare and uncommon animals;
- Regulating and limiting the impacts of development and hydrologic alterations on riparian forest used by state-listed animals;
- Managing protected riparian forests to remove exotic invasive species;
- Researching the natural history of riparian forest animals, including a focus on the Eastern Hognosed Snake to determine the actual distribution and population size in Massachusetts;
- Designing and initiating inventories of riparian forests, to supplement the report on floodplain forests published in 1999 with a report that includes management recommendations for wildlife habitats;
- Study impacts of invasive species on wildlife habitats in riparian forests; and
- Educate/inform the public about the values of these habitats and the issues related to their conservation through agency publications and other forms of public outreach in order to instill public appreciation and understanding

Monitoring Conservation Action Effectiveness

The effectiveness of these proposed conservation actions will be monitored by assessing the:

- Number and percentage of the Species Habitat Polygon delineations used in regulatory reviews and land protection planning;
- Number of research projects completed on riparian forest animal life histories;
- Number of surveys completed for undersurveyed riparian forest animals;
- Acres of riparian forests protected, supporting rare and uncommon animals;
- Number of proposed riparian forests alterations reviewed and regulated by DFW each year;
- Number of inventories of riparian forests completed, with a section on management of invasive species and wildlife habitat; and
- Number of conservation actions modified and adapted, using the results of monitoring.

References:

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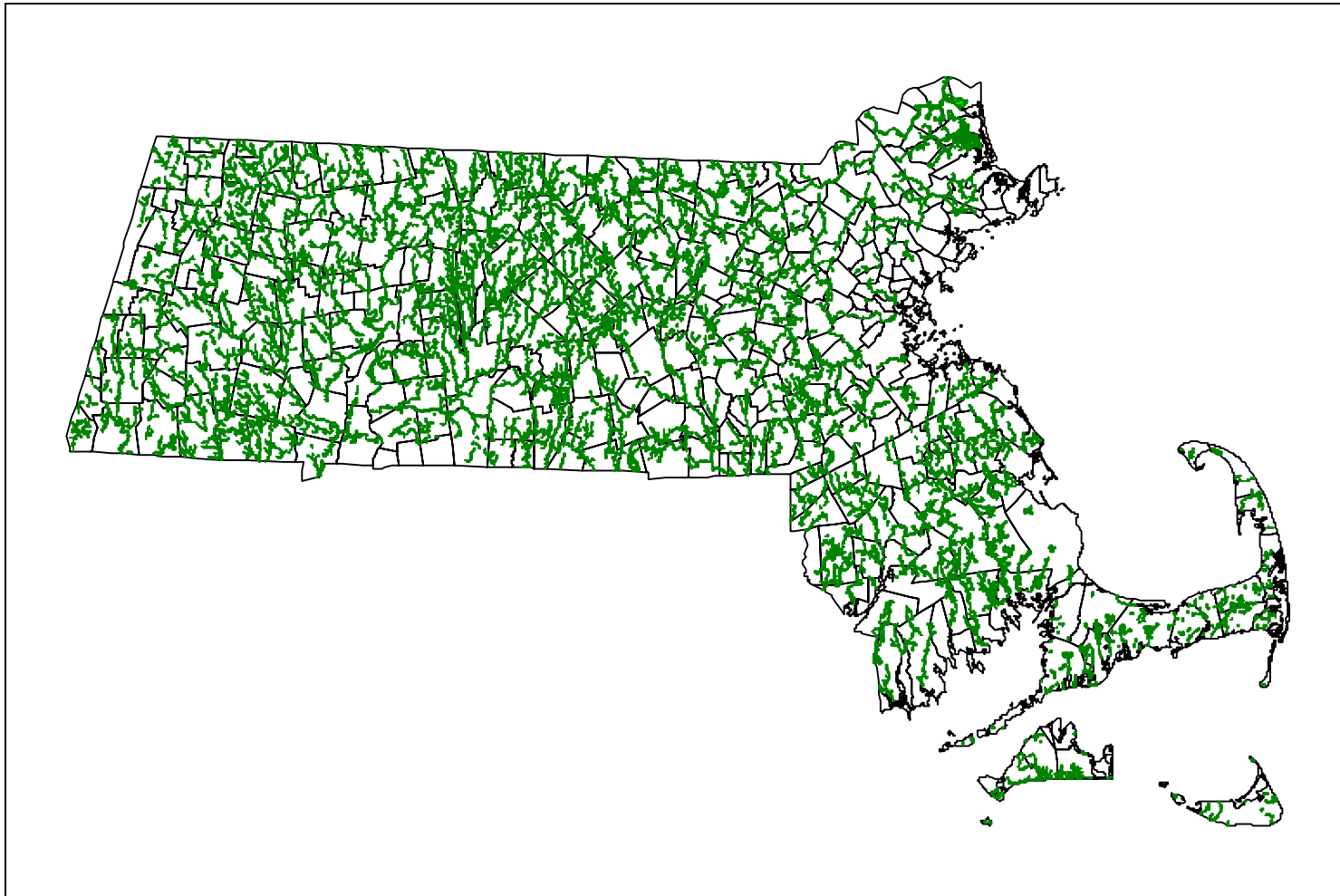


Figure 33: Riparian Forest along Major Watercourses in Massachusetts.

Data from MassGIS's Natural Riparian Corridor polygon with developed and agricultural lands removed. For the Cape and Islands, the MassGIS's Major Hydrography layer buffered by 100m, also with the developed and agricultural lands removed. Only riparian areas greater than 30 acres are shown.

C. Small-scale Habitats

1. Vernal Pools

Habitat Description

Vernal pools are ephemeral wetlands that fill annually from precipitation, runoff, and rising groundwater. Usually vernal pools in Massachusetts fill in the spring, and most years they become completely dry later in the season, losing water over the summer to evaporation and transpiration. This wet-dry cycle – a vernal pool’s hydroperiod – prevents fish from becoming established permanently in these seasonal wetlands, and thus presents a fish-free, if temporary, habitat for many species. Fish can and do eat many of the species in vernal pools, if given the chance.

In Massachusetts, vernal pools are relatively common, with a more-or-less even distribution across the state, except in highly urbanized areas. In 2000, NHESP analyzed springtime aerial photographs of the entire state, determining the locations of possible vernal pools from evidence of small water bodies or ground topography. These locations are called Potential Vernal Pools; some 30,000 were found statewide. A map of these Potential Vernal Pools is available as a GIS datalayer from Mass GIS, at <http://www.mass.gov/mgis/pvp.htm>. Figure 34, below, shows the locations of Potential Vernal Pools across the state. Most Potential Vernal Pools that have been field-checked have been found to be functioning vernal pools. However, locating vernal pools through aerial photo-interpretation misses very small pools, those under conifers, and small pools embedded in wooded swamps. Thus, potentially there are many more vernal pools in Massachusetts than the 30,000 found by aerial photointerpretation.

In Massachusetts, vernal pools can be “certified” under the Massachusetts Wetlands Protection Act. The certification process, which is administered by NHESP, involves documentation of biocriteria (breeding by obligate vernal pool species, for example) for each pool and review of those criteria by NHESP biologists, to achieve certification. Certified vernal pools receive extra protection under the state Wetlands Protection Act (M.G.L. c.131 s.40) and under some municipal wetlands bylaws. For more information on vernal pool certification, see <http://www.mass.gov/dfwele/dfw/nhesp/nhcvp.htm>. Figure 35, below, shows the locations of Certified Vernal Pools across Massachusetts, as of September, 2004. Note that, because the certification process is voluntary, the distribution of Certified Vernal Pools differs greatly from that of Potential Vernal Pools.

Species of Greatest Conservation Need in Vernal Pools

State Listing Status	Taxon Grouping	Scientific Name	Common Name	State Status
State-listed	Amphibians	<i>Ambystoma jeffersonianum</i>	Jefferson Salamander	SC
		<i>Ambystoma laterale</i>	Blue-Spotted Salamander	SC
		<i>Ambystoma opacum</i>	Marbled Salamander	T
		<i>Hemidactylium scutatum</i>	Four-Toed Salamander	SC
		<i>Scaphiopus holbrookii</i>	Eastern Spadefoot	T
	Reptiles	<i>Clemmys guttata</i>	Spotted Turtle	SC
		<i>Emydoidea blandingii</i>	Blanding’s Turtle	T
	Mammals	<i>Sorex palustris</i>	Water Shrew	SC
	Crustaceans	<i>Eubbranchipus intricatus</i>	Intricate Fairy Shrimp	SC
		<i>Eulimnadia agassizii</i>	Agassiz’s Clam Shrimp	E

State Listing Status	Taxon Grouping	Scientific Name	Common Name	State Status
Not Listed		<i>Limnadia lenticularis</i>	American Clam Shrimp	SC
	Odonates	<i>Aeshna mutata</i>	Spatterdock Darner	SC
	Snails	<i>Physa vernalis</i>	Vernal Physa	--
	Crustaceans	<i>Caenestheriella gynecia</i>	Feminine Clam Shrimp	--
	Beetles	<i>Hygrotus sylvanus</i>	Sylvan Hygrotus Diving Beetle	--

Jefferson, Blue-spotted, and Marbled Salamanders, Eastern Spadefoots, and Intricate Fairy Shrimp are obligate breeders in vernal pools, which means they must have vernal pools in which to breed successfully. Additionally, vernal pools support breeding common vertebrates, such as Wood Frogs (*Rana sylvatica*) and Spotted Salamanders (*Ambystoma maculata*), and invertebrates, such as fairy shrimp (*Eubranchipus* spp.). Many other common and rare animals use vernal pools for some aspect of their life history (feeding, breeding, over-wintering, estivating, hydrating, etc.), including Blanding's Turtles (Threatened), Spotted Turtles (Special Concern), Four-toed Salamanders (Special Concern), Eastern Box Turtles (Special Concern), Wood Turtles (Special Concern), Spring Peepers, Gray Treefrogs, Green Frogs, Leopard Frogs, Pickerel Frogs, American Toads, Fowler's Toads, Red-spotted Newts, Painted Turtles, Snapping Turtles, diving beetles, water scorpions, dragonflies and damselflies, dobsonflies, whirligig beetles, caddisflies, leeches, fingernail clams, and amphibious air-breathing snails. In particular, two damselflies, Emerald Spreadwing (*Lestes dryas*) and Lyre-tipped Spreadwing (*Lestes unguiculatus*), both of which are thought to be uncommon in Massachusetts and often found at vernal pools and interdunal swales, may be dependent on these fish-free water bodies for successful reproduction. However, the natural history of these two odonates is not well known.

Threats to Vernal Pools

Vernal pools and the animals that depend on them are threatened by outright destruction of the pool, by clearing of the forests surrounding pools, by pollution and sedimentation, by stocking with fish, by water withdrawals, by construction blasting in the vicinity, and by road mortality of animals moving to, from, and between vernal pools. Some, but not all, Certified Vernal Pools in Massachusetts are protected from these disturbances by the Massachusetts Wetlands Protection Act (M.G.L. c.131 s.40), and some municipalities in the state enact local bylaws which give enhanced protection to vernal pools beyond the state level.

While the destruction or degradation of vernal pools are obvious threats to vernal pool animals, two more insidious threats in Massachusetts are the clearing of forests around the pools and the destruction of forested corridors between vernal pools.

Many vernal pool animals, particularly reptiles and amphibians, inhabit the forests around the pools. These animals can range considerable distance from the vernal pools – up to 600 meters for Marbled Salamanders (Threatened) and up to 2 kilometers for Blanding's Turtles (Threatened). At best, the state Wetlands Protection Act (M.G.L. c.131 s.40) protects a buffer of 100 feet around a vernal pool, clearly not enough to protect the upland habitat of these animals. The state Endangered Species Act (M.G.L. c.131A) can be used to protect greater areas from development or other change, but this is a costly and time-intensive procedure, for both developers and state regulatory agencies.

Over a longer time and on a landscape-scale level vernal pool animals exist in meta-populations. Local populations using a single vernal pool may become extinct for a variety of natural reasons, yet the pool will be re-colonized from other nearby vernal pools with successful populations. Thus, over decades or centuries, regional populations of these animals are maintained, even though very local populations may become extinct. However, this occurs only if vernal pool animals can travel safely to other pools often over distances longer than their normal ranges. The fragmentation of Massachusetts by roads, buildings, and other human uses of the land has severely limited the ability of vernal pool animals to move between vernal pools to re-colonize isolated pools.

Conservation Actions

Proposed actions aimed at conserving vernal pool animals in the future include, assuming adequate funding:

- Determining site-specific Species Habitat Polygons for each current occurrence of a state-listed vernal pool animal, to inform land protection and regulatory priorities and actions;
- Conducting research into the impacts of development and habitat fragmentation on vernal pool species, particularly for the reptiles and amphibians which use vernal pools;
- Surveying for Water Shrew, Intricate Fairy Shrimp, Agassiz's Clam Shrimp, American Clam Shrimp, Spatterdock Darner, and Feminine Clam Shrimp to determine their range, abundance, and distribution in the state, as these species are undersurveyed in Massachusetts;
- Determining the minimum land area and habitat features needed to protect meta-populations of obligate vernal pool species, for use in conservation planning;
- Prioritizing clusters of vernal pools across the state as targets for survey and conservation efforts;
- Protecting land around vernal pools supporting populations of rare and uncommon animals;
- Synthesis of research and survey findings, with subsequent production of conservation guidelines;
- Producing conservation and recovery plans for suites of rare vernal pool animals;
- Certifying vernal pools;
- Educating the public and private sectors about the importance of vernal pools and how to certify and protect them, including continuing vernal pool workshops for educators;
- Regulating and limiting the impacts of development on vernal pools used by state-listed animals;
- Funding research on the natural history of vernal pool animals; and
- Educating and informing the public about the values of vernal pool habitats and the issues related to their conservation through agency publications and other forms of public outreach in order to instill public appreciation and understanding.

Monitoring Conservation Action Effectiveness

The effectiveness of these proposed conservation actions will be monitored by assessing the:

- Number and percentage of the Species Habitat Polygon delineations used in regulatory reviews and land protection planning;

- Number of research projects completed on vernal pool animal life histories, including the development of conservation and recovery plans;
- Number of surveys completed for undersurveyed vernal pool animals;
- Acres of land protected, through fee acquisition or conservation restriction, around vernal pools supporting rare and uncommon animals;
- Number of vernal pool certification applications processed each year;
- Number of proposed vernal pools alterations reviewed and regulated by DFW each year;
- Number of conservation management permits (part of regulation of proposed developments) monitored, when those permits were issued by DFW for vernal pool species; and
- Number of conservation actions modified and adapted, using the results of monitoring.

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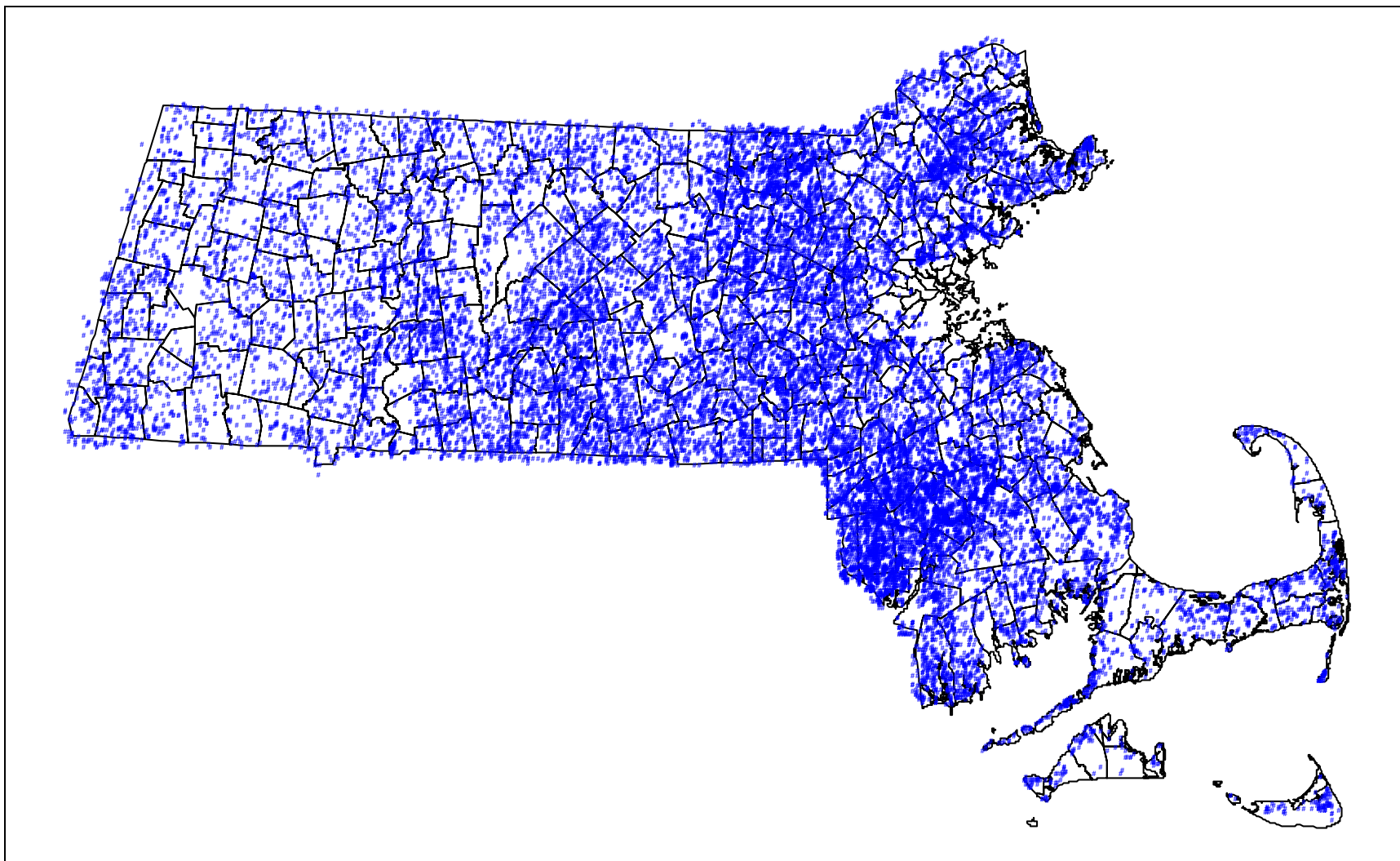


Figure 34: Potential Vernal Pools in Massachusetts.

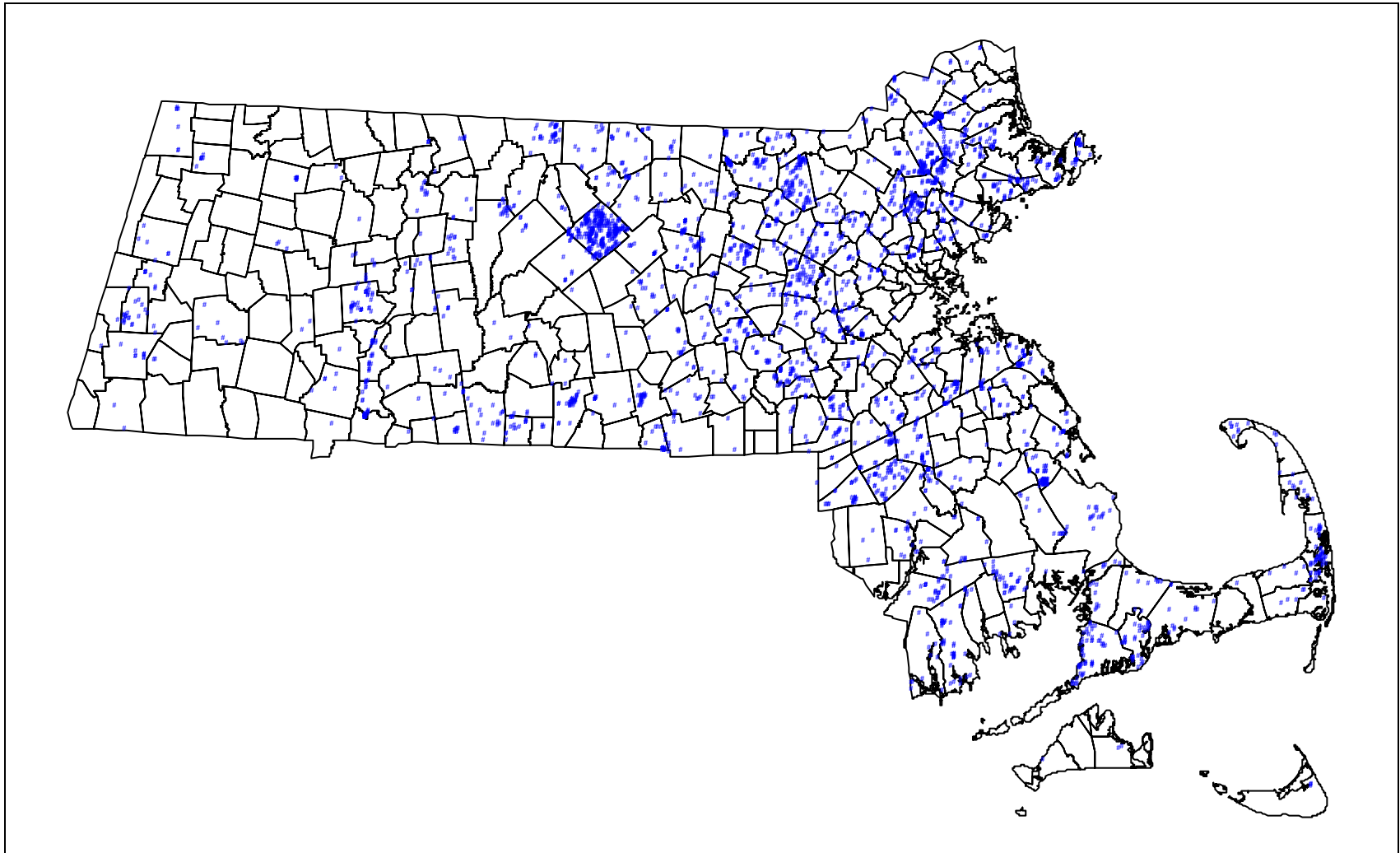


Figure 35: Certified Vernal Pools in Massachusetts.

2. Coastal Plain Ponds

Habitat Description

Coastal plain ponds are shallow, naturally low-nutrient, highly acidic groundwater ponds in sandy glacial outwash, usually with no inlet or outlet. Most of the coastal plain ponds in Massachusetts contain permanent water, but some are shallow basins where groundwater drops below the surface late in the growing season. Water rises and falls with changes in the water table, typically leaving an exposed shoreline in late summer. In wet years, the pond shore may remain inundated. The pond substrate varies from sand-cobble to muck.

In Massachusetts, coastal plain ponds are limited to the southeastern part of the state with some similar ponds on sand or gravel in the lower Connecticut Valley. In preparing for a study (Corcoran 2002) on coastal plain pondshores, the Massachusetts Natural Heritage & Endangered Species Program (NHESP) identified 329 ponds with potential coastal plain pondshore communities, of which 105 of the perceived best ponds were visited and qualitative information collected on the pond and shoreline. Of these, 96 were determined to be of sufficiently good quality (A to CD ranks) to enter into the NHESP database, with only 11 receiving an "A" rank. All but three of the A-ranked ponds are in conservation ownership. The main reason for the lower ranking of most of the coastal plain ponds was the presence of a zone of contribution to a public water supply well, which alters the natural hydrologic fluctuations that the ponds depend on for viability.

Most coastal plain ponds in Massachusetts have no natural streams flowing in or out, although since European settlement some have been connected to other wetlands, especially to function as reservoirs for cranberry bogs. Although the ponds are naturally connected to the groundwater during parts of the year, the connection may be lessened during the drier parts of the year. The bottoms of the pond consist of variably deep organic material that inhibits the movement of water. Along the upper sandy shore, water movement is not as restricted, and there are active, direct connections between the pond and the groundwater. In the winter, there is little evaporation and much precipitation, the groundwater and ponds rise, and the ponds become full. During leaf-out in the spring, trees increase their use of groundwater, evaporation increases from leaves and pond surfaces, and the groundwater recedes, lowering pond levels. Groundwater connections provide cool, low-nutrient water to ponds, and would normally enhance water quality. In areas with polluted groundwater, ponds can acquire the pollutants with negative effects on the habitat. This is especially true on Cape Cod.

Species of Greatest Conservation Need in Coastal Plain Ponds

State Listing Status	Taxon Grouping	Scientific Name	Common Name	State Status
State-listed	Reptiles	<i>Pseudemys rubriventris</i> pop I	Northern Red-Bellied Cooter	E
	Odonates	<i>Aeshna mutata</i>	Spatterdock Darner	SC
		<i>Anax longipes</i>	Comet Darner	SC
		<i>Enallagma laterale</i>	New England Bluet	SC
		<i>Enallagma pictum</i>	Scarlet Bluet	T
		<i>Enallagma recurvatum</i>	Pine Barrens Bluet	T

Coastal plain ponds and pondshores provide habitat for many species that occur almost exclusively on coastal plain ponds. Coastal plain pondshores are important habitat for dragonflies and damselflies (over 45 species are known to occur on coastal plain ponds and several of those species are rare). They are also important habitat for Painted, Musk, Spotted, and Snapping Turtles, and for the federally Endangered Northern Red-Bellied Cooters. Larger ponds and pondshores are used by migrating and wintering waterfowl, including Common and Hooded Mergansers, Goldeneye, and Bufflehead. Some of these ponds support warm-water fish and freshwater mussels. Coastal plain ponds can function as vernal pools when fish populations are absent.

The natural community on the pond shores is a good indicator of pond quality. It also provides habitat for turtle nests. Near-shore emergent plants are important sites for dragonflies and damselflies, which live amongst the submerged vegetation as larvae and climb onto the emergent vegetation to undergo metamorphosis to adults.

Threats to Coastal Plain Ponds

Multiple threats affect coastal plain ponds. The greatest threat is from water withdrawal, which lowers pond level and changes natural fluctuations. Shrub and tree encroachment threaten pondshores in areas with heavy water withdrawal. Periodic high water levels prevent tree and shrub encroachment, and seasonal low water is necessary to expose the pondshore. Excessive drawdown from pumping for water consumption reduces natural fluctuations and allows woody species to advance down the shores.

Coastal plain ponds have several other immediate and long-term anthropogenic threats. High nutrient leachate from nearby improperly maintained septic systems poses the long-term threat of pond eutrophication on these naturally low-nutrient ponds. Overwintering populations of Canada geese may provide sufficient nutrient enrichment to change the character of the ponds, allowing algae and pondweeds not native to the ponds to grow and reduce the habitat available to the native species, and to alter the habitat for animals. Large numbers of human swimmers can have the same effect. Vehicle use on pondshores during low water disturbs the characteristic vegetation, which is habitat for emerging dragonflies and damselflies, as well as for nesting turtles.

Research shows a distinct connection between coastal plain ponds and the surrounding groundwater. Because enormous pressures are put on all the water in an area to move towards a well, large-scale pumping has a larger effect than just lowering the water table in the vicinity of the wells. With an increasing number of wells in the vicinity of coastal plain ponds, there is a growing concern about the effects of pumping on the animals and plants that make up the natural communities of coastal plain ponds and their shores. The Massachusetts Division of Fisheries & Wildlife has made a concerted effort over the past several years to identify top-quality ponds, and to protect them through acquisition and regulation. Acquisition funds from several of the last few open space bonds have been used to acquire some relatively undisturbed ponds in the Town of Plymouth and on the Cape. Unfortunately, this has not always provided the protection from lowered water tables that is sought. The need for clean water sometimes leads water companies or water districts to view conservation areas as ideal locations for public water supplies, and they

haven't always considered the effects on the other resources. In addition, between the 1950s and the 1980s, the water table on Cape Cod was lowered by several feet.

Very few of our ponds have naturally low levels that leave the bottom of the ponds without standing water, although some of the ponds near large wells have been drawn down in the past few years. The effects on the animal life are not known. Dragonfly and damselfly larvae live among aquatic vegetation. Eggs and larvae may survive for a time either in the stalks of vegetation (where many species lay their eggs) or in the mud of drying ponds. Fortunately they disperse relatively well, and with nearby sources, a temporarily drawn down pond can have its insect life restored. If all ponds in an area are drawn down too often, that restocking is less likely. Frogs and turtles may be able to survive by moving to wet ponds, or digging into the drying mud. Again, survival depends on not having this occur too often, or over too large an area. As the water levels go down, any remaining organic material is subjected to oxidation and removal from the system, changing the water-holding capacity of the pond's substrate.

Emergent plants that are part of normal pond vegetation, or are enhanced by extra nutrients, can be perceived as a problem for human recreation; they are sometimes removed to make access easier or swimming more pleasant. Such emergents are important parts of the habitat of native fauna, hiding waterfowl nests, providing perches for other birds, and providing sites for odonates to emerge. Some ponds have been limed so that non-native fish can survive better in them, in the process changing the chemistry to which the native fauna are adapted.

As non-migratory goose populations have grown, besides enriching the waters of the ponds they live on, they graze the plants along the shores, sometime in such numbers as to change the proportions of different species and the resultant habitat for other animals.

Giant reed grass, *Phragmites*, is a plant that comes into disturbed areas, and once established is very difficult to eliminate. Fortunately, it now occurs in only a few of the coastal plain ponds. Where it does occur, it can become so dense that other species have no place to grow. It also changes the habitat for resident animals.

Proposed Conservation Actions

Proposed actions aimed at conserving rare and uncommon coastal plain pond species in the future include, assuming adequate funding:

- Determining Species Habitat Polygons for each current occurrence of a state-listed coastal plain pond animal;
- Surveying coastal plain ponds for Spatterdock Darter, Scarlet Bluet, Pine Barrens Bluet, and New England Bluet to determine their range, abundance, and distribution in the state, as these species are undersurveyed in Massachusetts;
- Protecting land around coastal plain ponds supporting populations of rare and uncommon animals;
- Regulating and limiting the impacts of development, nutrients, and water withdrawals on coastal plain ponds used by state-listed animals;
- Researching the natural history of coastal plain pond animals;
- Completing field surveys of possible coastal plain ponds, to supplement the report produced in 2002; and

- Educating and informing the public about the values of coastal plain ponds and the issues related to their conservation, through agency publications and other forms of public outreach in order to instill public appreciation and understanding.

Monitoring Conservation Action Effectiveness

The effectiveness of these proposed conservation actions will be monitored by assessing the:

- Number and percentage of the Species Habitat Polygon delineations used in regulatory reviews and land protection planning;
- Number of surveys completed for undersurveyed coastal plain pond animals;
- Acres of land protected around coastal plain ponds supporting rare and uncommon animals;
- Number of proposed coastal plain pond alterations reviewed and regulated by DFW each year;
- Number of research projects completed, on coastal plain pond animal life histories;
- Number of field surveys completed of possible coastal plain ponds;
- Number of conservation guidelines completed for coastal plain ponds;
- Number of conservation management permits (part of regulation of proposed developments) monitored, when those permits were issued by DFW for alterations in or near coastal plain ponds;
- Number of educational materials produced and disseminated about coastal plain ponds; and
- Number of conservation actions modified and adapted, using the results of monitoring.

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3. Springs, Caves and Mines

Habitat Description

Springs are formed when groundwater surfaces. They are found throughout the state in unconsolidated glacial deposits. In Berkshire County, springs and solution caverns are formed in extensive marble and dolomite rock formations, forming a complex elevated karst terrain. Caves are formed primarily by overhanging rock ledge and in spaces among the rocks of talus slopes. Caverns are formed when groundwater dissolves carbonate bedrock. Air temperature in caverns approximates the mean annual temperature of the county and varies according to the caverns' natural ventilation. Air and water temperatures in karst systems are relatively stable allowing species to have persisted perhaps even through glaciation events (Peck 1998).

Some of the taxa associated with karst systems may be hundreds of millions of years in age. Food sources are relatively sparse in groundwater systems, though organic materials are brought into karst systems by surface waters and fissures. As a result, groundwater foodwebs are less complex and less diverse than epigeal systems. Hypogean fauna are classified based upon their degree of reliance on groundwater. Stygophiles use groundwater habitats, but are not groundwater obligates, and stygobites are completely dependent on groundwater habitats (Gibert 1994). With no affinity for groundwater, the stygoxenes are accidentally present and provide important nutrients to stygophiles and stygobites. The transition zone between groundwater and surface waters is called the hyporheic zone. Recognition of this zone has led to increased understanding of the geochemical and ecological interactions between groundwaters and surface waters (Gibert 1997).

There are more than 70 documented caverns in Massachusetts and an unknown number of caves. None of these hypogean habitats, with great potential for supporting undescribed endemic animals, have been explored in Massachusetts. There are two thermal springs in the northwest corner of the state, one on unprotected land and the other developed as a bottled-water plant.

Abandoned mines in Massachusetts can also serve as a kind of cave or cavern habitat, particularly for hibernating bats. Most of the larger abandoned mines in the state have been surveyed for hibernating bats, but few have been checked for other spring, cave, or cavern animals.

Species of Greatest Conservation Need in Springs, Caves and Mines

State Listing Status	Taxon Grouping	Scientific Name	Common Name	State Status
State-listed	Misc. Invertebrates	<i>Polycelis remota</i>	Sunderland Spring Planarian	E
		<i>Gammarus pseudolimnaeus</i>	Northern Spring Amphipod	SC
	Crustaceans	<i>Stygobromus borealis</i>	Taconic Cave Amphipod	E
		<i>Stygobromus tenuis tenuis</i>	Piedmont Groundwater Amphipod	SC
	Mammals	<i>Myotis sodalis</i>	Indiana Myotis (Historic in MA)	E
		<i>Myotis leibii</i>	Eastern Small-footed Bat	SC

The Sunderland Spring Planarian is restricted to a cold spring in Sunderland, Massachusetts. This spring has water temperatures of 8.5 to 9.0 degrees Celsius throughout the year. The greatest concentration of this planarian can be found living in the spring, but some animals are found just downstream of the spring on the undersides of stones and cobbles.

In Massachusetts the Northern Spring Amphipod has only been observed at a few small calcareous springs and streams in southern Berkshire County. Elsewhere in its range, *G. pseudolimnaeus* is reported from lakes and large rivers, migrating to small streams and springs during the breeding season (Bousfield 1958). In Massachusetts, no *G. pseudolimnaeus* have been reported from lakes or rivers, though large concentrations have been observed in springs.

The stygobites include the Piedmont Groundwater Amphipod (*Stygobromus tenuis tenuis*) and Taconic Cave Amphipod (*S. borealis*). These are currently known from two sites and one site in Massachusetts respectively (Smith 1997).

Eleven mines and twelve caves have been documented to harbor wintering bats in Massachusetts. Only one hibernaculum has definitely supported the Eastern Small-footed Bats (the only extant state-listed bat species) within in the past 25 years. The Indiana Bat has not been found in Massachusetts since 1939. The maximum number of bats of all species using a hibernaculum in the Commonwealth ranges up to around 7,000, but many hibernacula have considerably fewer individuals. Mines have more wintering bats than do caves; up to a maximum of 7320 in mines, but only 110 in caves. In general, the number of bats using hibernacula in Massachusetts has increased over the past few decades (Cardoza et al., in prep). Figure 36, below, gives the approximate locations of known bat hibernacula in Massachusetts.

Bats that hibernate in Massachusetts can use any underground cavity, but most of the known large hibernacula have been in abandoned mines, as there are few caves in the state that are deep enough or long enough to have stable winter temperature regimes and thus support large numbers of wintering bats. Twelve of the 23 known hibernacula are natural caves, with a maximum number of 110 bats reported on any survey.

Known bat hibernacula in Massachusetts have been surveyed by the MDFW about every ten years, starting in the 1970s. The last series of surveys took place in the mid- to late 1990s. Three of the hibernacula are on protected conservation land, two are on town-owned properties that are not necessarily dedicated to conservation, and the other eleven sites are privately owned. Occasionally these sites are surveyed in the summer; however, no systematic data exist regarding summer concentrations of bats of any species.

In addition to the state-listed species, several other bat species have been documented using these sites as hibernacula, including Big Brown Bat (*Eptesicus fuscus*), Little Brown Bat (*Myotis lucifugus*), Northern Myotis (*M. septentrionalis*, formerly *M. keeni*), and Eastern Pipistrelle (*Pipistrellus subflavus*). Little Brown Bats are by far the commonest bats at hibernacula, with thousands found at the biggest hibernacula, followed by Northern Myotis and Eastern Pipistrelle, usually found up to a few hundred at most, and finally Eastern Small-footed Bat and Big Brown Bat, in the low single digits, if at all.

The Indiana Bat, which is federally listed as Endangered, is considered to be of historic status in Massachusetts. The best-documented occurrence was in the 1930s (with a maximum of 60 individuals ever found at one site) and the species has not been found again, despite repeated searches of the original location.

Threats to Springs, Caves and Mines

Among the many threats to the integrity of springs, caves, caverns, and mines in Massachusetts are the following:

- Contamination by pollutants introduced accidentally, such as fertilizers and terrestrial organic matter;
- Pollutants introduced to purify drinking water;
- Excessive groundwater withdrawal;
- Gravel mining;
- Vandalism;
- Overuse by recreational spelunkers; and
- Poor understanding of hydrology and ecology of groundwater systems.

In Massachusetts, threats specific to bat hibernacula include disturbance of wintering bats by spelunkers, rock collectors, or vandals, and destruction of abandoned mine shafts by natural cave-ins.

Proposed Conservation Actions

Proposed actions aimed at conserving rare and uncommon spring, cave and mine species in the future include, assuming adequate funding:

- Determining, to the extent possible, Species Habitat Polygons for each current occurrence of a state-listed spring, cave and mine animal;
- Surveying for spring, cave and mine invertebrates statewide to determine their range, abundance, and distribution in the state, as these species are undersurveyed in Massachusetts;
- Updating documented sites for rare spring, cave and mine animals, and surveying nearby suitable habitat for these species;
- Surveying for bat hibernacula on a regular and continuing schedule to determine the use and species composition of hibernacula across the state;
- Managing bat hibernacula so as to limit detrimental impacts from human use or other factors, for example by installing gates;
- Producing conservation and recovery plans for bats which use hibernacula in Massachusetts;
- Protecting land around springs, caves and mines supporting populations of rare and uncommon animals;
- Regulating and limiting the impacts of development, gravel mining, pollutants, and water withdrawals on springs, caves and mines used by state-listed animals;
- Researching the natural history of spring, cave and mine animals;
- Educating state residents about the ecological benefits of bats; and

- Educating/informing the public about the values of spring, cave and mine habitats and the issues related to their conservation through agency publications and other forms of public outreach in order to instill public appreciation and understanding.

Monitoring Conservation Action Effectiveness

The effectiveness of these proposed conservation actions will be monitored by assessing the:

- Number and percentage of the Species Habitat Polygon delineations used in regulatory reviews and land protection planning;
- Number of research projects completed on spring, cave and mine animal life histories;
- Number of surveys completed for undersurveyed spring, cave and mine animals;
- Number of management actions implemented to limit deleterious effects on hibernating bats;
- Number of surveys of known bat hibernacula, on a continuing and regular basis;
- Number of research projects on the natural history and analysis of existing data on rare and uncommon bat species completed;
- Acres of land protected around springs, caves and mines supporting rare and uncommon animals;
- Number of proposed spring, cave and mine alterations reviewed and regulated by DFW each year; and
- Number of conservation actions modified and adapted, using the results of monitoring.

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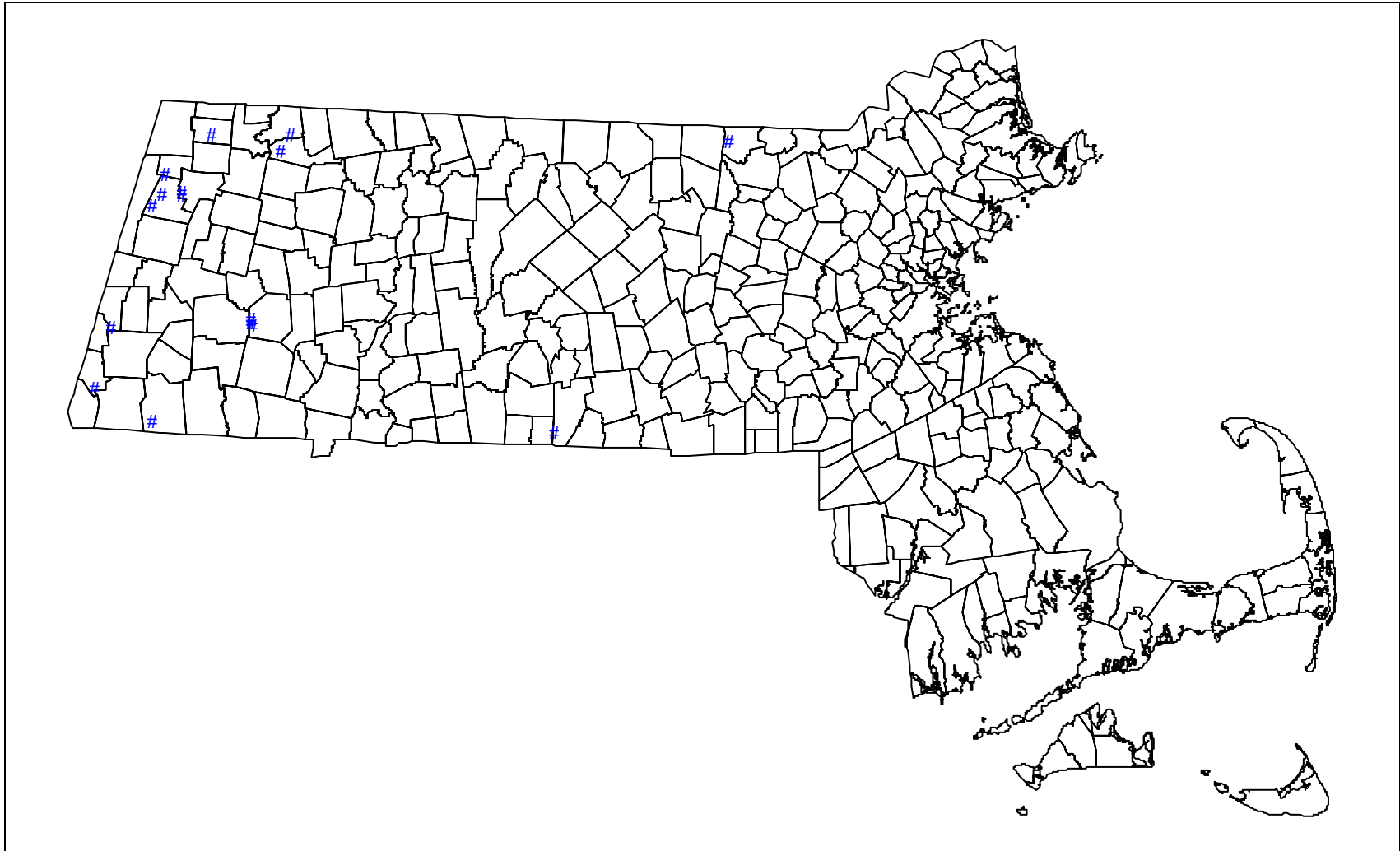


Figure 36: General Locations of Known Bat Hibernacula in Massachusetts.

4. Peatlands and Associated Habitats

Habitat Description

Peatlands are freshwater wetlands where plants grow on partially decomposed plant remains. The “soil” – peat – is usually saturated for most of the year (if not, it decomposes). Deep peat separates the plants from the mineral soil and its nutrients, leaving vegetation composed of plants adapted to low-nutrient, usually acidic, wet conditions. Peatlands can be forested or open. Peatland areas often include a mosaic of forested, shrub-covered, and open peatlands.

Bogs are among the best-known peatlands and generally have the thickest peat. Bog communities receive little or no streamflow and they are isolated from the water table, making them the most acidic and nutrient-poor of peatland communities. The pH of bogs is in the range of 3 to 4. Bogs occur in a variety of physical settings such as along pond margins, at the headwaters of streams, in kettleholes, or in isolated valley bottoms without inlet or outlet streams. They occur statewide, although most are in the north-central and western parts of the state. Most are dominated by dwarf ericaceous shrub species growing on sphagnum moss, generally with pronounced hummock-hollow topography. Forested bogs are late-successional peatlands that typically occur on thick peat deposits. Most forested bogs are dominated by spruce or tamarack, although some, mostly in the southeastern part of the state, have an open canopy in which Atlantic white cedar is the characteristic tree species.

Fens are shallower peatlands where plants have more access to mineral water and, so, to more nutrients. They tend to be less acidic than bogs. Acidic fens tend to have more diversity of plant species than do bogs. Acidic graminoid fens typically have some standing water present throughout much of the growing season. Peat mats are quaking and often unstable. Calcareous fens (rich fens), in Massachusetts, found only in the southwestern part of the state where groundwater carries calcium dissolved from surrounding limestone or marble, support a generally different flora than occurs in acidic fens. Even in the calcium-rich areas, other nutrients are not readily available. In areas with calcareous fens, cold upwelling groundwater with few nutrients assists in maintaining peat. Calcareous fens are open, sedge-dominated wetlands occurring on slight to moderate slopes where there is calcareous groundwater seepage. They are rare species “hot spots” with many associated rare plant and animal species.

Bogs and fens are often surrounded by more nutrient-rich, wetter moats with muck rather than peat, dominated by a mixture of highbush blueberry and swamp azalea. Inside the moats, the peat mat supports a mixture of tall and short shrubs that are predominantly ericaceous (members of the Heath family). Leatherleaf is dominant. Other typical ericaceous shrubs include rhodora, sheep laurel, and low-growing large and small cranberry. Scattered, stunted coniferous trees (primarily tamarack and black spruce) occur throughout, with scattered red maple, and occasional pines. A mixture of specialized bog plants grow on the hummocky sphagnum surface, including carnivorous pitcher plants and sundews.

Shrub-dominated acidic peatlands are characterized by a mixture of primarily deciduous shrubs. The species and conditions overlap with shrub swamps, but tend to be less diverse. Acidic shrub fens experience some groundwater and/or surface water flow, but not calcareous seepage. Acidic

shrub fens are typically found along wet pond margins in the eastern half of the state, but they also characterize many wet pond margins in northern Worcester County.

Species of Greatest Conservation Need in Peatlands and Associated Habitats

State Listing Status	Taxon Grouping	Scientific Name	Common Name	State Status
State-listed	Amphibians	<i>Hemidactylium scutatum</i>	Four-Toed Salamander	SC
	Birds	<i>Botaurus lentiginosus</i>	American Bittern	E
	Mammals	<i>Synaptomys cooperi</i>	Southern Bog Lemming	SC
	Odonates	<i>Aeshna subarctica</i>	Subarctic Darner	T
		<i>Somatochlora forcipata</i>	Forcipate Emerald	SC
		<i>Somatochlora georgiana</i>	Coppery Emerald	E
		<i>Somatochlora incurvata</i>	Incurvate Emerald	T
		<i>Somatochlora kennedyi</i>	Kennedy's Emerald	E
		<i>Williamsonia fletcheri</i>	Ebony Boghaunter	E
		<i>Williamsonia lintneri</i>	Ringed Boghaunter	E
	Lepidoptera	<i>Apamea inebriata</i>	Drunk Apamea Moth	SC
		<i>Apamea mixta</i>	Coastal Plain Apamea Moth	SC
		<i>Callophrys hesseli</i>	Hessel's Hairstreak	SC
		<i>Callophrys lanoraieensis</i>	Bog Elfin	T
		<i>Cingilia catenaria</i>	Chain Dot Geometer	SC
		<i>Hemaris gracilis</i>	Slender Clearwing Sphinx Moth	SC
		<i>Metarranthis pilosaria</i>	Coastal Swamp Metarranthis	SC
		<i>Papaipema appassionate</i>	Pitcher Plant Borer	T
		<i>Papaipema stenocelis</i>	Chain Fern Borer	T
Not Listed	Amphibians	<i>Rana pipiens</i>	Northern Leopard Frog	--
	Reptiles	<i>Thamnophis sauritus</i>	Eastern Ribbon Snake	--
	Birds	<i>Zonotrichia albicollis</i>	White-throated Sparrow	--
	Beetles	<i>Hygrotus sylvanus</i>	Sylvan Hygrotus Diving Beetle	--

The high acidity and low oxygen content of the water make bogs inhospitable to many reptiles, fish, and amphibians. However, several of the state's listed rare animal species are found in bogs. Peatlands include a diversity of habitats within them. Many invertebrates specialize on the plants that are peatland specialists. Pools in the peat support several rare species of dragonflies. The Sylvan Hygrotus Diving Beetle has not been located recently, but specimen records indicate that it was found in temporary pools in fens, with one in a small pond. Moats and pools associated with all types of bogs can function as vernal pool habitat, if they have two to three months of ponding and lack fish; they provide important amphibian breeding habitat.

Sphagnum or sedge hummocks over open water provide nesting habitat for Four-toed Salamanders. Scattered populations of Southern Bog Lemmings are found in areas with a mix of herbaceous and shrubby vegetation, where they make runs and nests in sphagnum and among roots of shrubs. Sphagnum mats where pitcher plants grow provide habitat for the rare Pitcher Plant Borer Moth.

The basic habitat of Bog Turtles is open-canopy wetlands with rivulets between sedge tussocks, such as are found in open calcareous fens. Other turtles, such as Spotted Turtles, also use these

habitats. Wood Turtles use these habitats if they are connected with the flowing waters of streams, brooks, tributaries, and smaller rivers associated with riparian corridors. Calcareous fens are particularly sensitive to changes in water level and type, and to added nutrients. They are extremely uncommon habitats, and many of the rare species in them are restricted to such habitats.

Large animals such as Black Bear use peatlands as part of their habitat. Blueberries and cranberries are favored foods when available. Pruning from deer browse on shrubs in and around peatlands is often obvious, as are moose and deer trails and bedding signs in sedge areas. Small birds nest in the dense shrub thickets in and around peatlands. Cover from the shrubs and trees are important parts of the habitat provided by peatlands for most animals that occur in them. Mallards, Black Ducks, and Wood Ducks nest on peat edges when there is open water.

Threats to Peatlands and Associated Habitats

Peatlands are maintained by the presence of cold, low-nutrient water. Altering the amount of water, adding nutrients, or increasing its temperature all threaten peatlands. The presence of peat makes bogs and fens different from other wetlands, and provides the distinct habitat that specialist species need. Mining peat is a clear threat, although uncommon in Massachusetts. Road runoff carrying salts has allowed invasion and expansion of *Phragmites* into peatlands. All peat is susceptible to decomposition from trampling. Heavily visited sites need unintrusive boardwalks.

Proposed Conservation Actions

Proposed actions aimed at conserving rare and uncommon peatland species in the future include, assuming adequate funding:

- Determining Species Habitat Polygons for each current occurrence of a state-listed peatland animal;
- Completing the field surveying and ranking of peatlands, to supplement the reports of 1994 and 1999;
- Surveying for Southern Bog Lemming, Spatterdock Darner, Subarctic Darner, Forcipate Emerald, Coppery Emerald, Incurvate Emerald, Kennedy's Emerald, and Sylvan Hygrotus Beetle to determine their range, abundance, and distribution in the state, as these species are undersurveyed in Massachusetts;
- Examining the results of the Massachusetts Reptile and Amphibian Atlas to determine the status of Northern Leopard Frog and Eastern Ribbon Snake;
- Protecting land around peatlands supporting populations of rare and uncommon animals;
- Regulating and limiting the impacts of development, nutrient additions, and water withdrawals on peatlands used by state-listed animals;
- Researching the natural history of peatland animals; and
- Educating/informing the public about the values of peatland habitats and the issues related to their conservation through agency publications and other forms of public outreach in order to instill public appreciation and understanding.

Monitoring Conservation Action Effectiveness

The effectiveness of these proposed conservation actions will be monitored by assessing the:

- Number and percentage of the Species Habitat Polygon delineations used in regulatory reviews and land protection planning;
- Number of inventories completed for undersurveyed peatland habitats, such as forested peatlands;
- Number of research projects completed on peatland animal life histories;
- Number of surveys completed for undersurveyed peatland animals;
- Acres of land protected around peatland supporting rare and uncommon animals;
- Number of proposed peatland alterations reviewed and regulated by DFW each year; and
- Number of conservation actions modified and adapted, using the results of monitoring.

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5. Marshes and Wet Meadows

Habitat Description

Marshes and wet meadows are some of the most important inland habitats for numerous species of animals, both rare and common. As defined here, this habitat type includes deep and shallow emergent marshes, wet meadows, kettlehole wet meadows, coastal interdunal marshes/swales, calcareous sloping fens, calcareous seepage marshes, calcareous basin fens, and acidic graminoid fens. These natural communities are described briefly below; see Swain and Kearsley (2000) for more detail on each of these.

Sections of most of these natural communities – the edges of emergent marshes adjacent to uplands, for example – can be free of fish and may function as vernal pools, attracting breeding Wood Frogs and Spotted Salamanders, as well as other animals that breed, feed, or rehydrate in vernal pools.

Deep Emergent Marsh

Deep emergent marshes generally form in broad, flat areas bordering low-energy rivers and streams or along pond and lake margins. The soils are a mixture of organic and mineral components. There is typically a layer of well-decomposed organic muck at the surface overlying mineral soil. There is standing or running water during the growing season and throughout much of the year. Water depth averages between 6 inches and 3 feet. Deep emergent marshes are associated with shrub swamps, and the two communities intergrade.

Shallow Emergent Marsh

Shallow emergent marshes occur in settings similar to those of deep emergent marshes, i.e., in broad, flat areas bordering low-energy rivers and streams, often in backwater sloughs, or along pond and lake margins. Unlike deep emergent marshes, shallow marshes commonly occur in abandoned beaver flowages, and in some states this type of natural community is named “abandoned beaver meadows” or “beaver flowage communities.” The soils are a mixture of organic and mineral components. There is typically a layer of well-decomposed organic muck at the surface overlying mineral soil. There is standing or running water during the growing season and throughout much of the year, but water depth is less than deep emergent marshes and averages less than 6 inches.

Wet Meadow

Wet meadows occur in lake basins, wet depressions, along streams, and in sloughs and other backwater areas with impeded drainage along rivers. The mucky mineral soils are permanently saturated and flood occasionally, but standing water is not present throughout the growing season, as in deep and shallow emergent marshes. As these communities flood only temporarily, continued disturbance is necessary to prevent encroachment by woody plants.

Kettlehole Wet Meadow

Kettlehole wet meadows are a variant of wet meadows that are restricted to glacial kettleholes in sandy outwash soils that have seasonal water level fluctuations. They are seasonally inundated by local runoff and groundwater fluctuations, and they typically have no inlet or outlet. For most of the summer, they look like shallow ponds, but by late summer they are covered by emergent

vegetation. Soils are typically shallow, mucky peats. Deep peat does not develop due to the seasonal drawdown of water. The hydrology of kettlehole wet meadows is similar to coastal plain ponds. Both are characterized by a series of plant associations occurring along a gradient from the higher, drier margins to the lower, wetter centers. Kettlehole wet meadows can function as vernal pool habitat if water remains standing for 2-3 months; these areas provide important amphibian breeding habitat.

Coastal Interdunal Marsh/Swale

Interdunal swales are low, shallow depressions that form between sand dunes along the coast. They occur as part of a dune system, and the best examples are complexes of numerous swales. Soils generally have a thin organic layer (about 1 cm) over coarse sand. The water regime ranges from seasonally flooded to permanently inundated.

Calcareous Sloping Fen

These fens are open, sedge-dominated wetlands occurring on slight to moderate slopes where there is calcareous groundwater seepage. Calcareous sloping fens are the most nutrient- and species-rich of the three calcareous fen communities described in Massachusetts. They are rare species "hot spots" with many associated rare plant and animal species. Where there is heavy groundwater discharge, the mineral soil is exposed. There can also be small hummocks of organic matter accumulation. Sites that are more highly disturbed have less woody shrub growth.

Calcareous Seepage Marsh

This natural community is a mixed herbaceous/graminoid/shrub wetland, which experiences some calcareous groundwater seepage. Calcareous seepage marshes are intermediate in richness of the three calcareous fen communities described in Massachusetts. This community type is found in a variety of physical settings - in basins, in canopy gaps in rich forested swamps, in current or former beaver drainages, or in level to slightly sloping sites associated with sloping fens. There are typically 50-200+ cm of moderately to well-decomposed organic sediments.

Calcareous Basin Fen

Calcareous basin fens are sedge-shrub peatlands occurring in well-defined basins that have calcareous groundwater, and sometimes surface water, inputs. Calcareous basin fens are the least rich of the three calcareous fen communities described in Massachusetts. Calcareous basin fens occur in well-defined basins with deep organic sediments, permanently saturated conditions, and consolidated or floating, sedge-dominated organic mats. Based on sediment core information from one such fen in western Massachusetts, this community appears to have existed at the site for a few thousand years and there is no evidence of rapid infilling or terrestrialization.

Acidic Graminoid Fen

Acidic graminoid fens are mixed graminoid/herbaceous acidic peatlands that experience some groundwater and/or surface water flow, but no calcareous seepage. Shrubs occur in clumps but are not dominant throughout. Acidic graminoid fens typically have some surface water inflow and some groundwater connectivity. Inlets and outlets are usually present, and standing water is present throughout much of the growing season.

Species of Greatest Conservation Need in Marshes and Wet Meadows

State Listing Status	Taxon Grouping	Scientific Name	Common Name	State Status
State-listed	Reptiles	<i>Clemmys muhlenbergii</i>	Bog Turtle	E
	Birds	<i>Podilymbus podiceps</i>	Pied-Billed Grebe	E
		<i>Botaurus lentiginosus</i>	American Bittern	E
		<i>Ixobrychus exilis</i>	Least Bittern	E
		<i>Circus cyaneus</i>	Northern Harrier	T
		<i>Rallus elegans</i>	King Rail	T
		<i>Gallinula chloropus</i>	Common Moorhen	SC
		<i>Cistothorus platensis</i>	Sedge Wren	E
		<i>Ammodramus henslowii</i>	Henslow's Sparrow	E
	Mammals	<i>Sorex palustris</i>	Water Shrew	SC
	Snails	<i>Vertigo perryi</i>	Olive Vertigo	SC
	Odonates	<i>Enallagma laterale</i>	New England Bluet	SC
	Lepidoptera	<i>Apamea inebriata</i>	Drunk Apamea Moth	SC
		<i>Apamea mixta</i>	Coastal Plain Apamea Moth	SC
		<i>Bagisara rectifascia</i>	Straight Lined Mallow Moth	SC
		<i>Euphyes dion</i>	Dion Skipper	T
		<i>Neoligia semicana</i>	Northern Brocade Moth	SC
		<i>Pieris oleracea</i>	Eastern Veined White	T
		<i>Spartiniphaga inops</i>	Spartina Borer	SC
	Amphibians	<i>Rana pipiens</i>	Northern Leopard Frog	--
Not Listed	Reptiles	<i>Thamnophis sauritus</i>	Eastern Ribbon Snake	--
	Birds	<i>Anas rubripes</i>	American Black Duck	--
		<i>Butorides virescens</i>	Green Heron	--
		<i>Porzana carolina</i>	Sora	--
	Lepidoptera	<i>Macrochilo bivittata</i>	Two-striped Cord Grass Moth	--

A number of other species of conservation concern are found in marshes and wet meadows, including: Jefferson Salamander (*Ambystoma jeffersonianum*, SC), Blue-spotted Salamander (*Ambystoma laterale*, SC), Marbled Salamander (*Ambystoma opacum*, T), Four-Toed Salamander (*Hemidactylium scutatum*, SC), Eastern Spadefoot (*Scaphiopus holbrookii*, T), Spotted Turtle (*Clemmys guttata*, SC), Wood Turtle (*Clemmys insculpta*, SC), Blanding's Turtle (*Emydoidea blandingii*, T), Upland Sandpiper (*Bartramia longicauda*, E), Southern Bog Lemming (*Synaptomys cooperi*, SC), Northern Spring Amphipod (*Gammarus pseudolimnaeus*, SC), Taconic Cave Amphipod (*Stygobromus borealis*, E), Agassiz's Clam Shrimp (*Eulimnadia agassizii*, E), American Clam Shrimp (*Limnadia lenticularis*, SC), Pitcher Plant Borer Moth (*Papaipema appassionate*, SC), Chain Fern Borer Moth (*Papaipema stenocelis*, SC), Ebony Boghaunter (*Williamsonia fletcheri*, E), and Ringed Boghaunter (*Williamsonia lintneri*, E). These species are more commonly associated with other habitats, such as vernal pools and grasslands, and are covered under those habitat sections.

Many other more common animals use marshes and wet meadows for feeding, nesting, roosting, cover, and movement corridors. There are too many such species to list, but some obvious examples are Bullfrogs, Garter Snakes, Ribbon Snakes, Great Blue Herons, Red-winged Blackbirds, White-tailed Deer, Muskrats, crayfish, and many dragonflies and damselflies.

Threats to Marshes and Wet Meadows

Wet meadows and emergent marshes are threatened by filling and dredging, impoundments that alter natural water-level fluctuations, and nutrient inputs from adjacent roads, fields, or septic systems. Purple Loosestrife (*Lythrum salicaria*) and Phragmites (*Phragmites australis*), two aggressive non-native species, can be abundant in marshes and wet meadows throughout the state. These two invasive exotics may displace native food plants of marsh and wet meadow animals, and may also provide a sufficiently different physical structure that nesting, roosting, and movement of these animals may be impeded.

Beaver activity threatens calcareous fen communities by altering surface water chemistry. There is evidence to suggest that ponding of water by beaver dams may increase the water's relative acidity, possibly due to the accumulation of organic acids or to dilution from acid rain.

For kettlehole wet meadows in particular, it is known that seasonal water level fluctuations play an important role. Spring high-water levels prevent encroachment of woody shrubs and trees, and late-summer low-water levels allow the characteristic narrow-leaved emergent plants to appear. Any alteration in natural water level fluctuations, such as groundwater withdrawal, will negatively affect the community.

Marshes and wet meadows can and do occasionally burn during low water periods, but the role of fire in community dynamics is not known. Fires, grazing, and/or mowing may be necessary to maintain open fen habitats.

Conservation Actions

Proposed actions aimed at conserving rare and uncommon marsh and wet meadow species in the future include, assuming adequate funding:

- Determining Species Habitat Polygons for each current occurrence of a state-listed marsh and wet meadow animal, for use in prioritizing land protection, regulation, and management actions;
- Locating large marshes and wet meadows state-wide via aerial photointerpretation, and field-surveying a selected percentage of these sites for rare and uncommon animals;
- Surveying for rare and uncommon marsh and wet meadow Lepidoptera, especially Two-striped Cord Grass Moth (*Macrochilo bivittata*), to determine their range, abundance, and distribution in Massachusetts;
- Determining the current status of rare and uncommon marsh and wet meadow birds across the state, through systematic call-back and other survey methods;
- Monitoring invasive plants and their impacts;
- Protecting land in and around marshes and wet meadows supporting populations of rare and uncommon animals;
- Regulating and limiting the impacts of development, nutrient inputs, and water withdrawals on marshes and wet meadows used by state-listed animals; and
- Researching the natural history of marsh and wet meadow animals.

Monitoring Conservation Action Effectiveness

The effectiveness of these proposed conservation actions will be monitored by assessing the:

- Number and percentage of the Species Habitat Polygon delineations used in regulatory reviews and land protection planning;
- Number of research projects completed on marsh and wet meadow animal life histories;
- Number of surveys completed for undersurveyed marsh and wet meadow animals;
- Acres of land protected around marshes and wet meadows supporting rare and uncommon animals;
- Number of proposed marsh and wet meadow alterations reviewed and regulated by DFW each year; and
- Number of conservation actions modified and adapted, using the results of monitoring.

References

Massachusetts Natural Heritage & Endangered Species Program. Various dates. Fact sheets on state-protected rare plants and animals, and on selected natural communities. Westborough, Massachusetts.

Swain, P.C., and J.B. Kearsley. 2000. *Classification of the Natural Communities of Massachusetts*. Draft. Massachusetts Natural Heritage & Endangered Species Program, Westborough, Massachusetts.

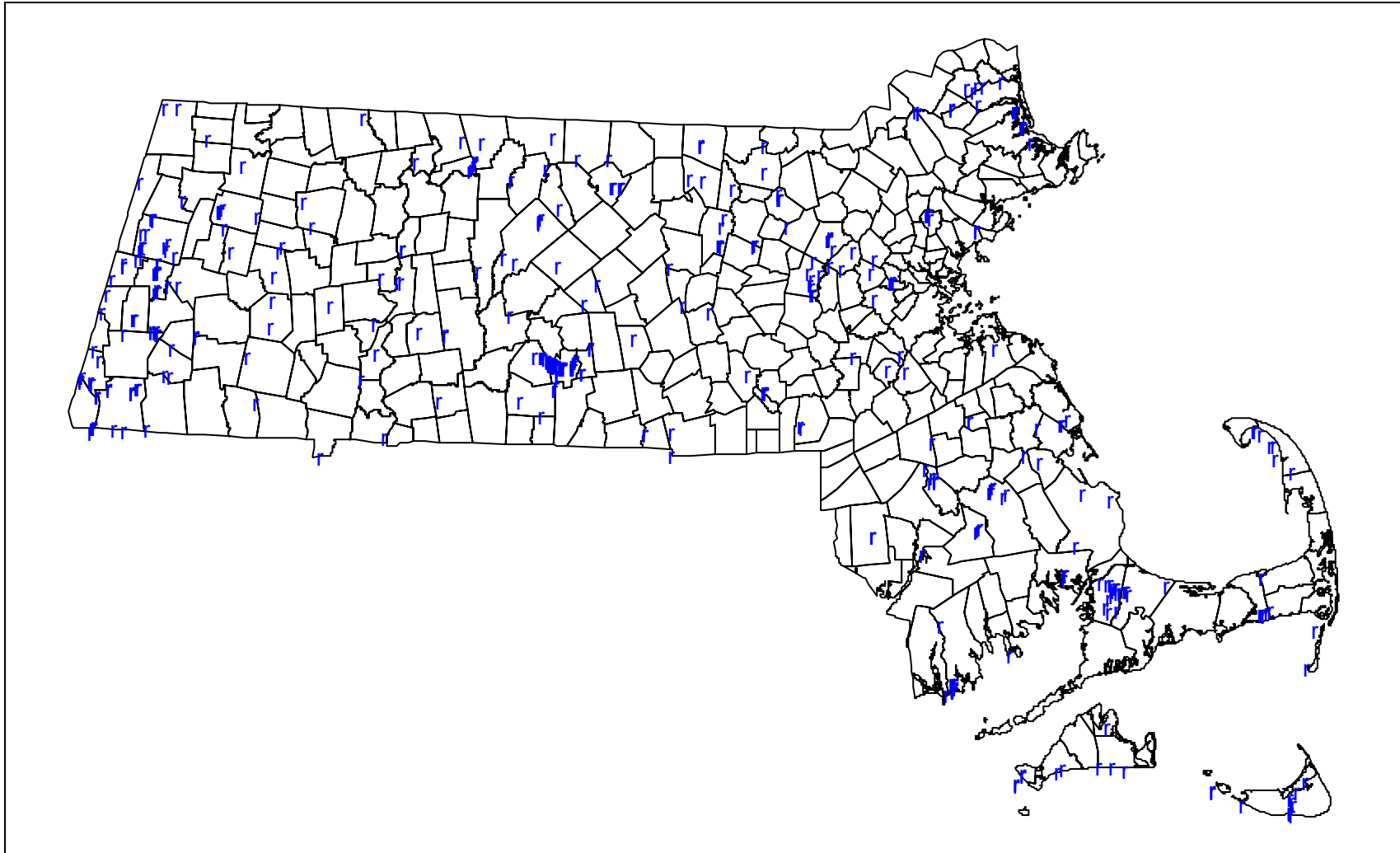


Figure 37: Locations of Marshes and Wet Meadows in Massachusetts.

6. Rocky Coastlines

Habitat Description

Animal species of conservation concern in this habitat are primarily using the sea along these coastlines for feeding and resting; occasionally they will roost or haul themselves out on the rocks for short periods.

In Massachusetts, only small areas of the coastline are significantly rocky (see Figure 38). Along the mainland coast, Cape Ann, consisting of the towns of Rockport, Gloucester, and Manchester-by-the-Sea, has rock cliffs along most of its coast. Southward along the coast, there are occasional rocky points here and there, many of which are heavily built up with homes. Cape Cod has a few areas of scattered rocks, but as the peninsula is mostly moraines left from glacial retreats, very little of the Cape has much bedrock at the surface. However, the southern shore of the lower Cape, along Buzzards Bay, is largely rocky, but not with the bedrock cliffs characteristic of Cape Ann. Rather, here the rocks are the remnants of a terminal moraine. On the Islands, only Martha's Vineyard has a rocky coastline, along its western edge. The Elizabeth Islands, separating Buzzards Bay and the Vineyard Sound, have rock along much of their shorelines.

Species of Greatest Conservation Need in Rocky Coastlines

State Listing Status	Taxon Grouping	Scientific Name	Common Name	State Status
Not Listed	Birds	<i>Clangula hyemalis</i>	Long-tailed Duck	--
		<i>Histrionicus histrionicus</i>	Harlequin Duck	--
		<i>Somateria mollissima</i>	Common Eider	--

Very large flocks of Long-tailed Ducks and Common Eiders winter on Massachusetts' offshore waters (see the section on Marine and Estuarine Habitats), and smaller flocks of these two species feed inshore, often along rocky coastlines. Inshore flocks of Common Eiders can range up to a thousand or more birds, while the maximum number of Long-tailed Ducks in near-shore flocks tend to be an order of magnitude smaller. Occasionally, all these of these birds may mingle at a single site, but in general the flocks tend to consist of a single species.

Long-tailed Ducks are not known to breed in Massachusetts, but a few Common Eiders have been documented to nest in the state. In the early 1970s, Common Eider chicks from Maine were released on Penikese Island and some of these bred on the island in subsequent years. From this beginning, Common Eiders have spread to breed on the nearby Elizabeth Islands. Other known breeding locations are Shag Island in the outer Boston Harbor and Bird Island in Marion.

Small flocks of Harlequin Ducks, up to about 30 birds at a site, winter along Massachusetts' rocky coastlines, but the species is not known to breed in the state. According to Veit and Petersen (1993), traditional wintering sites for Harlequin Duck include "the rocks off the Hammond Castle in Magnolia, the Glades at North Scituate, the east shore of Cape Cod at East Orleans, and the Squibnocket Cliffs at Martha's Vineyard. Generally, they prefer rocky, granitic shores such as those at Cape Ann; however, on Cape Cod and the Islands, they frequent stretches of beach where only scattered rocks exist."

Other birds that feed or nest along rocky coastlines in Massachusetts include Common and Red-throated Loons; Horned and Red-necked Grebes; Great and Double-crested Cormorants; White-winged, Black, and Surf Scoters; Purple Sandpipers; and Great Black-backed, Herring, Ring-billed, and other gulls, as well as a number of other birds in smaller numbers.

Massachusetts allows hunting of Common Eider and Long-tailed Ducks, with a current daily bag limit of seven seaducks (scoters, eiders, and Long-tailed Duck combined), and a possession limit of 14 seaducks. In 1999 Massachusetts reduced the bag for eiders from seven birds to four, with a limit of one hen. Hunting of Harlequin Ducks is not allowed in Massachusetts. In 2004-2005, the season for both Common Eider and Long-tailed Ducks was open October 6 - January 22.

Threats to Animals of Rocky Coastlines

Hunting has been identified as possibly contributing to the long-term decline of Common Eider and, possibly, Long-tailed Duck numbers (Goudie et al. 2000, Robertson and Savard 2002). It is unclear if hunting of seaducks in Massachusetts is a major contributor to seaduck declines. The most recent estimates of sea duck harvests for Massachusetts are in Table 14, below. These estimates are based on USFWS Harvest Information Program (H.I.P.) survey results. The confidence limits for any given year are broad, but the average over several years may give a reasonable idea of general harvest levels.

Table 14. Annual Harvest of Seaducks in Massachusetts.

Year	Long-tailed Duck	Common Eider
1999	400	4,600
2000	200	4,300
2001	700	13,400
2002	0	2,400

More likely threats to these species are the detrimental effects of over-harvesting of their prey species, coastal pollution, and disturbance of wintering flocks or nesting pairs by human activities (Goudie et al. 2000). These activities include recreational and commercial boating along the coast, hikers and other recreationalists on land immediately along the shore, and erection of structures such as docks, seawalls, and wind turbines. An occasional threat will be oiling and subsequent mortality of these species during oil spills. Oil spills during the winter months could have a very large impact on these birds, as there is a significant potential for a spill to intersect large flocks of wintering birds at that time.

Common Eiders also die as a result of entanglement in fishing and aquaculture nets (Hoopes 1992). Nets are also documented as a source of mortality for Long-tailed Ducks, at least on the Great Lakes (Robertson and Savard 2002).

Excessive mortality of adult Common Eiders, Long-tailed Ducks, and most other seaducks is of concern, because of the life history strategies of these species: They take longer to reach sexual maturity than other ducks; there is a low survival rate of eggs, chicks, and first-year birds; and not all adults of reproductive age attempt nesting every year (Goudie et al. 2000, Robertson and

Savard 2002). With such a life history strategy (as in Blanding's and other turtles) rates of adult mortality as low as a few percent per year can lead to long-term population declines.

Although rocky coastlines have occasionally been quarried for use as building material, it is unlikely that this currently poses much of a deleterious impact on wintering seaducks feeding along these coasts.

Conservation Actions

Proposed actions aimed at conserving rare and uncommon rocky coastline species in the future include (assuming adequate funding):

- Annual surveying for Long-tailed Duck (wintering) and Common Eider (wintering and breeding) to determine their range, abundance, and distribution in the state;
- Improving the accuracy of numbers of harvested seaducks;
- Systematic, intensive, long-term surveying of wintering Harlequin Ducks, which are not easily surveyed from the air, as the Atlantic population of this species is apparently declining;
- Protecting rocky coastlines supporting populations of rare and uncommon animals from on-shore development, excessive recreational use, and construction of docks, piers, jetties, and other structures in the water near shore;
- Researching the natural history of animals using rocky coastlines, with attention to any impacts to food sources and to possible deleterious effects of human uses of these coasts and the immediately adjacent waters;
- Educating/informing the public about the values of rocky coastline habitats and the issues related to their conservation through agency publications and other forms of public outreach in order to instill public appreciation and understanding.

Monitoring Conservation Action Effectiveness

The effectiveness of these proposed conservation actions will be monitored by assessing the:

- Number and percentage of the Species Habitat Polygon delineations used in regulatory reviews and land protection planning;
- Number of surveys and research projects completed on the range, abundance, distribution, and natural history of seaducks using rocky coastlines for wintering or breeding;
- Acres of land protected along rocky coastlines supporting rare and uncommon animals;
- Number of proposed rocky coastline alterations reviewed and regulated by DFW each year;
- Number of conservation management permits (part of regulation of proposed developments) monitored, when those permits were issued by DFW for rocky coastline species; and
- Number of conservation actions modified and adapted, using the results of monitoring.

References

Goudie, R.I., G.J. Robertson, and A. Reed. 2000. Common Eider (*Somateria mollissima*). In *The Birds of North America*, No. 546 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, Pennsylvania.

Hoopes, E. M. 1992. Entanglement of common eiders in clam culture nets. *Bird Observer* 20(5): 258-259.

Robertson, G.J., and J. P. L. Savard. 2002. Long-tailed Duck (*Clangula hyemalis*). In *The Birds of North America*, No. 651 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, Pennsylvania.

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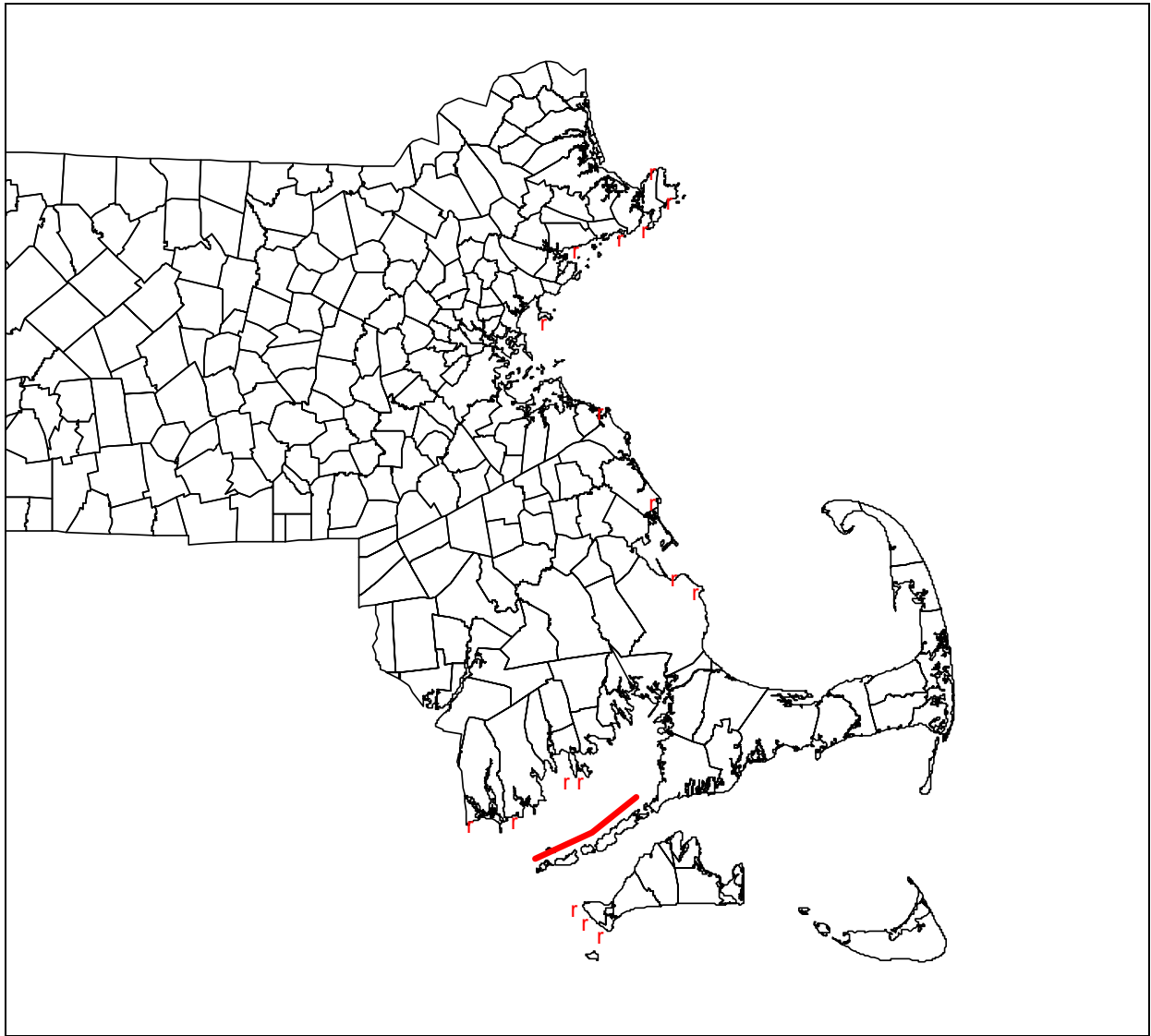


Figure 38: Locations of Major Rocky Points and Coastlines in Massachusetts.

7. Rock Cliffs, Ridgetops, Talus Slopes, and Similar Habitats

Habitat Description

This habitat type is a composite of several separate and distinctive natural communities, but often these natural communities are adjacent to each other (e.g., a rock cliff may have a talus slope below it and a rocky ridgetop and open rock outcroppings above it). The animals of conservation concern associated with these different natural communities often inhabit all of these adjacent rocky habitats and may move amongst them over the course of a day or a season.

In Massachusetts, rock cliffs, talus slopes, and rocky ridgetops and outcroppings may be of acidic, circumneutral, or calcareous bedrock, and may be open to the sun or partially to mostly shaded by woodland forest. Often there is little soil formed on these areas, in part because of steepness and the resulting rapid erosion, but also because these areas are likely to be well-drained, open to the drying effects of the wind and sun, and subject to more frequent fire than many lowland areas. Small fires started by lightning or people in these rocky areas are likely to spread more than similar fires in lowland areas because the litter in rocky areas is drier, and fire suppression efforts are likely to be more difficult. Wind storms, ice storms and boulder slides also influence vegetation composition and structure on ridgetops and talus slopes.

The bedrock of these areas may be resistant enough to have withstood survived the erosive effects of glaciers, or may be soft enough that a river can create a cliff or ledge by eroding quickly through the rocky layers of bedrock. An example of rock cliffs composed of resistant bedrock is the basalt of the Mt. Tom range in the Connecticut River Valley. These basalt layers slant upward to the west. Glaciers eroded away softer rock on top of and west of this basalt, leaving a sheer, open rock wall on the west side of the mountain, with a large talus slope at the bottom of the cliff and a rocky ridgetop above. Further north in the Connecticut River Valley, the soft red sandstone of the North and South Sugarloaf hills was eroded greatly by the glaciers during glaciation, but it is likely that the east-facing sandstone cliff of South Sugarloaf resulted from the Connecticut River cutting quickly down through the rock during the relatively fast draining of glacial Lake Hitchcock.

See Swain and Kearsley (2000) for more details on the plant communities and other details of the several types of rocky area natural communities recognized in Massachusetts: acidic, circumneutral, or calcareous varieties of rock cliffs, rocky summit/rocky outcrops, and talus forest/woodland.

Rocky areas of these types are found throughout much of Massachusetts (see Figure 39), with the exception of southeastern Massachusetts, Cape Cod, and the Islands. Worcester County has many rolling hills, with only a few areas of rock cliffs, ridgetops, and talus slopes, while Berkshire County and the western parts of Franklin, Hampshire, and Hampden Counties are more mountainous and have many more instances of these rocky habitats than the rest of the state.

Species of Greatest Conservation Need in Rock Cliffs, Ridgetops, Talus Slopes, and Similar Habitats

State Listing Status	Taxon Grouping	Scientific Name	Common Name	State Status
State-listed	Reptiles	<i>Elaphe obsoleta</i>	Eastern Ratsnake	E
		<i>Agkistrodon contortrix</i>	Copperhead	E
		<i>Crotalus horridus</i>	Timber Rattlesnake	E
	Birds	<i>Falco peregrinus</i>	Peregrine Falcon	E
	Mammals	<i>Sorex dispar</i>	Rock Shrew	SC
	Beetles	<i>Cicindela rufiventris hentzii</i>	Hentz's Redbelly Tiger Beetle	T
	Lepidoptera	<i>Catocala herodias gerhardi</i>	Gerhard's Underwing	SC
		<i>Hemaris gracilis</i>	Slender Clearwing Sphinx Moth	SC
		<i>Rhodoecia aurantiago</i>	Orange Sallow Moth	T
Not Listed	Reptiles	<i>Coluber constrictor</i>	Black Racer	--

In Massachusetts three species of state-listed snakes – Eastern Ratsnake, Copperhead, and Timber Rattlesnake – are primarily inhabitants of rocky areas and surrounding forest. All three snakes -- frequently joined by more common species such as the Black Racer (*Coluber constrictor*), Milk Snake (*Lampropeltis triangulum*), and Garter Snake (*Thamnophis sirtalis*) -- winter in communal dens (hibernacula) that are usually located in crevices in south- or west-facing talus slopes. Talus slopes offer good drainage and passageways to deep underground chambers where temperatures remain above freezing during even the harshest winters. While dens can be located in other habitats, in Massachusetts talus slopes are the usual location for winter dens.

Historically, Peregrine Falcons nested on natural cliffs in Massachusetts. About 14 historic Peregrine aeries have been identified, but currently almost all Peregrine nests are on tall buildings or large bridges above major rivers. In 2002, a pair of Peregrines nested on a natural cliff for the first time since the middle of the last century. That nesting attempt failed and the pair did not re-nest at that site in 2003. However, in 2003, a pair (possibly the same pair) nested successfully on a natural cliff elsewhere in the Connecticut River Valley. Several historic aerie sites are still suitable for Peregrine nesting, as best as can be determined and may be occupied in the future. While the number of nesting pairs of Peregrines has rebounded in Massachusetts over the past decades (11 pairs recorded in 2004), those numbers have yet to reach historic levels, and thus, natural nest sites may still be re-colonized in the future. It is likely, however, that rock-climbers and Great Horned Owls at some cliff sites disturb prospecting pairs of falcons sufficiently to keep the birds from nesting.

Rock Shrews inhabit shaded, cool talus slopes and crevices in rock cliffs and outcroppings located within coniferous forests in Berkshire County. Often these sites are hemlock ravines or old-growth forests with abundant mosses and lichens. In addition to obvious habitat alterations such as development, heavy logging of these sites, or hemlock die-off due to Woolly Adelgid infestation, may render these areas unsuitable for Rock Shrews, although this is not certain.

On the other end of the state, Hentz's Redbelly Tiger Beetle is found on the tops of granite hills around Boston, usually in parks established in the late 1800s. These beetles prefer open areas of

rock outcrops and prey on small invertebrates. Development of these hilltops or overuse by hikers and picnickers can destroy the habitat for this species.

Three rare moths in Massachusetts are found in rocky areas. It is possible probable that these three moths of rocky areas were considerably more widespread when the landscape was more open and large fires could not be easily suppressed were much more frequent; now these moths are restricted to rocky areas and other habitats still subject to occasional fire. The caterpillars of each of them are dependent for food on specific plants: Gerhard's Underwing larvae eat Scrub Oak leaves (*Quercus ilicifolia*); Slender Clearwing Sphinx Moth larvae eat Lowbush Blueberry leaves (*Vaccinium pallidum*); and Orange Sallow Moth larvae eat the unripe seeds of several species of False Foxgloves (*Aureolaria* spp.). All of these plants are fire-dependent and thrive in conditions created by periodic fire: Vigorous growth, seed production, and dispersal of these species are best right after fires. Rocky areas in Massachusetts are more likely to burn than many natural habitats, probably because suppression of natural or anthropogenic fires is more difficult in steep, rocky areas.

Rocky areas, especially cliffs, ridgetops, and talus slopes, are not suitable for agriculture or productive forestry. As a result, these areas have never been plowed, and typically were not as subject to the degree of clearing and subsequent grazing in the mid-1800s as less steep and less rocky areas.

Many common animals use rock cliffs, ridgetops, and talus slopes for nesting or denning, including the Common Raven, (*Corvus corax*), Turkey Vulture (*Cathartes aura*), Porcupine (*Erethizon dorsatum*), Eastern Coyote (*Canis latrans*), and a variety of small rodents. Other animals of conservation concern that use these areas are the Bobcat (*Lynx rufus*), Marbled Salamander (*Ambystoma opacum*), and bats.

For more information on state-protected rare animals of rocky areas, see the NHESP fact sheets, the source for some of the information above.

Threats to Rock Cliffs, Ridgetops, Talus Slopes, and Similar Habitats

One major impact to these rocky areas and the rare animals they support is human recreational use. Ridgetops and rock cliffs often have human trails running along their summits. Increasingly, these trails are used not just by hikers, but also by riders of mountain bikes, off-road vehicles, and snowmobiles, all of which cause greater erosion of the trails than hikers. They also cause damage to trails and vegetation and alter natural run-off patterns. The steeper slopes and cliffs tend to attract rock climbers. Peregrine Falcons nesting on rock-climbing cliffs or near trails may be sufficiently disturbed by humans to abandon these sites, either just for that season or as a possible nest site at all. When people encounter Eastern Ratsnakes, Copperheads, or Timber Rattlesnakes, the snakes are often collected or killed. Because these snakes concentrate at traditional wintering dens, discovery of these den sites by people can be particularly deleterious to the local population of snakes, as it is easy for all the snakes using a den to be captured or killed. Beyond these obvious threats of human use, hikers can trample vegetation on delicate clifftops, destroying the food plants required by the larvae of rare moths of these areas.

The other major threat to rocky areas in Massachusetts is quarrying. Several types of quarrying are likely to destroy habitat for rock-dwelling rare animals: basalt (traprock) and sandstone quarries on the ridges of the Connecticut River valley; limestone and marble quarries in the Berkshires; and granite quarries in many parts of the state from the Boston suburbs westward. When quarries are abandoned, the area may eventually revert to habitat suitable for rare animals, but more often, quarries leave flattened areas bare of all but planted grass and invasive weeds – land which is ripe for residential or commercial development, despite the costs of building on rock.

Proposed Conservation Actions

Proposed actions aimed at conserving rare and uncommon rocky area species in the future include (assuming adequate funding):

- Determining Species Habitat Polygons for each current occurrence of a state-listed animal from rock cliffs, ridgetops, talus slopes, and similar habitats, for use in prioritizing land protection, regulation, and management activities;
- Surveying for Rock Shrew, Gerhard's Underwing, Slender Clearwing Sphinx Moth, and Orange Sallow Moth to determine their range, abundance, and distribution in the state, as these species are undersurveyed in Massachusetts;
- Determining the dens and seasonal movement of Eastern Ratsnake, Copperhead, and Timber Rattlesnake, as the full extent of habitat used by these snakes is not known;
- Educating/informing landowners and visitors, of land inhabited by the Copperhead and Timber Rattlesnake, about appropriate actions for encounters with venomous snakes and about protection of these species under state law;
- Determining where trails and rock-climbing sites interfere with rare animals, and taking steps to re-route trails, educate hikers and climbers, and direct climbers to less sensitive sites or impose seasonal closures;
- Conducting controlled burns of rocky areas where fire has been an important agent in keeping these areas suitable for rare animals;
- Protecting rock cliffs, ridgetops, talus slopes, and similar habitats supporting populations of rare and uncommon animals;
- Regulating and limiting the impacts of development, quarrying, and recreational use on rock cliffs, ridgetops, talus slopes, and similar habitats used by state-listed animals; and
- Researching the natural history of animals from rock cliffs, ridgetops, talus slopes, and similar habitats.

Monitoring Conservation Action Effectiveness

The effectiveness of these proposed conservation actions will be monitored by assessing the:

- Number and percentage of the Species Habitat Polygon delineations used in regulatory reviews and land protection planning;
- Number of research projects completed on animal life histories using rock cliffs, ridgetops, talus slopes, and similar habitats;
- Number of surveys completed for undersurveyed rocky area animals;
- Number of management efforts completed to benefit rocky area animals;
- Acres of land protected, supporting rare rocky area animals;
- Number of proposed rocky area alterations reviewed and regulated by DFW each year; and

- Number of conservation actions modified and adapted, using the results of monitoring.

References

Leonard, J.G., and R.T. Bell. 1999. *Northeastern Tiger Beetles: a Field Guide to Tiger Beetles of New England and Eastern Canada*. CRC Press, Boca Raton, Florida.

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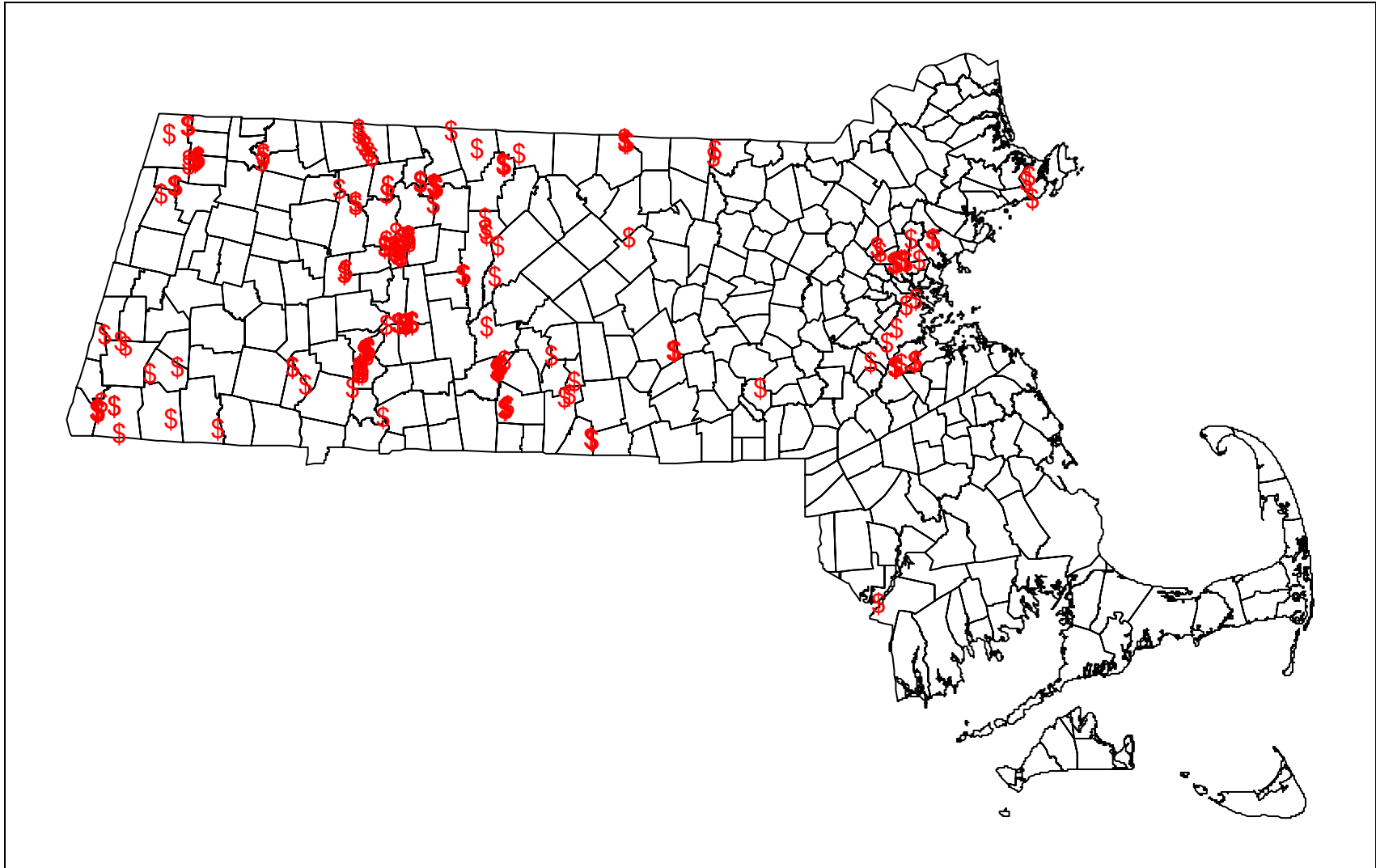


Figure 39: Locations of Some Rocky Cliffs, Ridgetops, Talus Slopes, and Similar Habitats in Massachusetts.